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ABSTRACT

This publication examines various topics and issues related to the world oil situation. Major areas considered are: (1) the nature and consequences of the current oil glut; (2) a historical overview of the petroleum era (with analyses of the three time periods of 1900-1973, 1973-1979, and 1979-1981); (3) the geopolitics of oil (including data on oil production and revenues from the Organization of Petroleum Exporting Countries (OPEC) for 1973, 1980, and 1984; (4) the limits to world oil use (explained by graphs on world oil reserves and data on oil production, reserves, and reserves/production ratios of 12 major oil producing countries); (5) energy efficiency and new energy sources (listing major sources and consumption rates from 1973 to 1984); and (6) energy policy framework (with trend analysis and political implications). It has been recognized that opportunities have been increasing for many countries in energy self-sufficiency and oil dependency has diminished. (ML)

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World Oil: Coping With the Dangers of Success

Christopher Flavin

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The world oil situation has changed dramatically in the past five years. The average price of oil has declined from its peak of over $35 per barrel in early 1981 to just $27 in 1985, helping to dampen inflation and boost economic recovery in many countries. The Middle East's share of world oil trade fell from 58 percent in 1979 to 40 percent in 1984. The Organization of Petroleum Exporting Countries (OPEC) is in disarray. Its official prices and production quotas are regularly violated by most member countries. About half of the oil traded internationally is sold on a competitive international spot market.[1]

The shift in the energy debate was sudden and largely unforeseen by energy planners. In the late seventies, opinion was virtually unanimous that further oil price increases and continuing heavy oil dependence were inevitable. The Worldwatch Institute is among dozens of research groups, private companies, and governments that expected oil prices to surpass $50 per barrel during the eighties. Petroleum industry studies predicted that world oil production would reach at least 90 million barrels per day before peaking between 1985 and 1995. Actual oil production in 1985 will average some 58 million barrels per day, down sharply from its historical peak of almost 66 million barrels in 1979.[2] (See Figure 1.)

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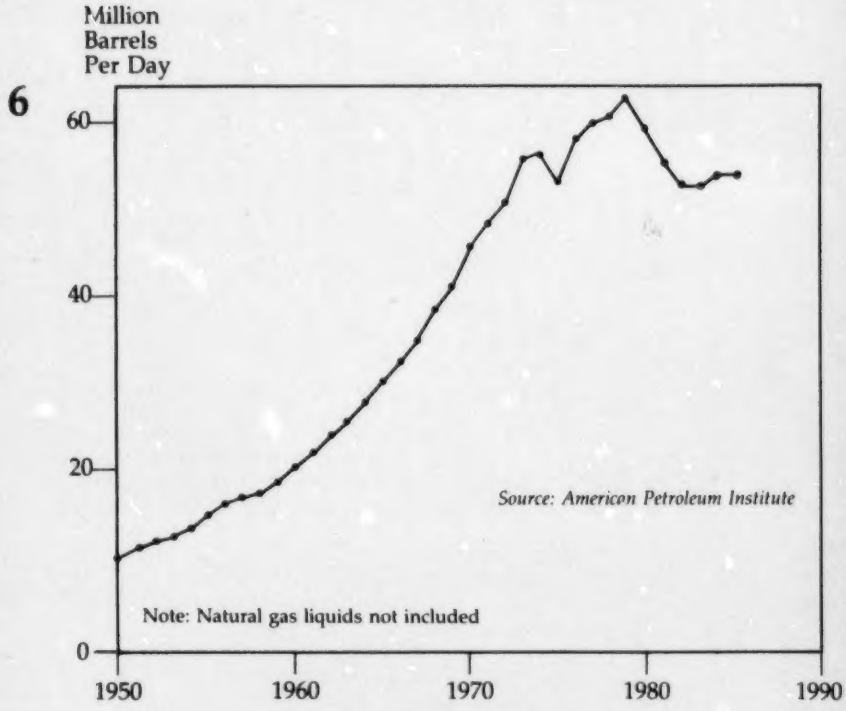

Figure 1: World Oil Production, 1950-85

The term "oil glut" is often used to describe the current world energy situation. It is apt in the sense that world oil production capability now greatly exceeds demand, and in this buyer's market, oil prices continue to slide. But "glut" implies a temporary situation that quickly ends as market forces are brought to bear. The new world oil situation, in contrast, represents a profound and extended change. In 1985, after three years of "glut," downward pressure on world oil

"After three years of 'glut,' downward pressure on world oil prices is actually strengthening."

prices is actually strengthening. Demand for OPEC oil, the world's marginal supplier, is falling for the sixth year in a row and is already down almost 50 percent from its peak.

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Oil is by far the world's most important fuel and its most heavily traded commodity—about $3 billion worth of oil products are used each day. It is hard to imagine how virtually all of the world's planners and forecasters could have been so wrong about something that is so central to the world economy. Two elements are key. One is that analysts tend to make predictions that extrapolate past trends. They were virtually hypnotized by oil's extraordinarily steady growth rate of 7 percent annually in the postwar period—leading to a nearly sixfold increase between 1950 and 1973. Analysts also expected developing countries, with two-thirds of the world's population, to move rapidly into the petroleum age, which would have made continuing rapid growth in oil consumption inevitable.

In retrospect, energy analysts would have done far better applying simple economic theory to their oil forecasts. Eight years of rapidly rising oil prices, culminating in spot market prices of over $40 per barrel in the early eighties, was an enormous incentive to use less oil and to find and develop more. Oil consumption plummeted, partly due to a severe economic recession, but largely due to rising energy efficiency. Coal, natural gas, renewable energy sources, and nuclear power have replaced oil in many applications. And new non-OPEC oil supplies equal to about 5 million barrels per day have been developed since 1979.

Thanks in part to lower oil prices, political leaders are basking in the glow of the recent worldwide economic recovery and the lowest inflation rates in a decade. No longer do energy issues dominate the agendas of international economic summit meetings; government debates often center on whether to eliminate the energy policies and research programs of the seventies. With so many other pressing national and international issues, attention is naturally moving away from energy, and investments are moving into other industries. If world energy markets are working so well, many wonder, why should we continue worrying about them?

The world energy outlook is not nearly so serene as the standard indicators show, however. Many nations are still suffering from high oil prices. The rise in value of the dollar—the currency in which oil is generally traded—has caused the real cost of oil to remain steady or rise in many countries. The continuing high cost of energy has contributed to Europe's economic malaise and has severely damaged many Third World economies. Some of the world's poorest nations, including most of those in Africa, are now virtually priced out of the oil market. Unable to pay for oil or for the investments needed to create non-oil-based economies, Third World nations are in danger of becoming trapped in an economic underclass.

Heavy reliance on coal is another potential hazard that clouds the world's energy future. Although coal use has not grown as rapidly as projected, it contributes an important and growing share of the world energy budget. Accelerating damage to forests and estuaries by coal-fired air pollution raises doubts as to whether the world can afford to have largely coal-based economies. New technologies may eventually reduce some types of coal-related air pollution. Other forms of pollution, especially climate-threatening carbon dioxide concentrations, are not amenable to pollution controls.

The current energy situation is inherently unstable and may carry the seed of its own undoing. As oil prices continue to fall, they will increasingly undermine future investments in energy efficiency and alternative energy sources, slowing the move away from oil. A growing number of analysts believe that oil markets are so weak that a sudden decline in oil prices to $15-$20 per barrel is possible. Low oil prices would eventually reverse the current worldwide move away from oil dependence, laying the groundwork for a future energy crisis.

One of the most ominous trends in recent years is the accelerated depletion of some of the world's most limited oil reserves, all outside the Middle East. The high price of oil has made it economical to greatly increase oil drilling in dozens of non-OPEC countries, many of which will soon reach a point of diminishing returns. Oil production in some regions, including North America, Europe, and the Soviet Union, is likely to begin falling steeply during the next decade.

Some 56 percent of proven oil reserves are still found in the Persian Gulf region. Sometime in the nineties the locus of world oil power will move back to the Middle East, which could eventually dominate world markets as never before.

Most assessments of the world energy outlook predict relatively smooth changes, with prices slowly rising or falling, and oil's role gradually phasing out. But the real world has so far failed to act like the predictable world of a modeler's equation, and world energy markets show no sign of coming into such an equilibrium anytime soon. Oil is one of the world's most unequally distributed resources, and as long as it dominates world energy markets, no real equilibrium is likely or perhaps even possible.

With the 1979-81 round of oil price increases, the world moved into uncharted terrain. The oil glut brings many benefits to the world economy, but blessings are mixed, and they may eventually contribute to a new energy crisis. The world faces not a steady rise in oil prices and a gradual shift to alternative energy sources, but rather a continuing series of upheavals that will send conflicting signals to decision makers.

Oil in Transition

The petroleum era can be divided into three periods. From 1900 until 1973, oil consumption roughly doubled every decade, and oil prices declined. First in North America, then in Europe, and finally in almost every corner of the globe, petroleum became the main fuel of economic growth and essential to everyday life. The second period, beginning in 1973, was marked by the Arab oil embargo of 1973 and the Iranian revolution of 1979, which allowed OPEC to push the average world price of oil from $2 per barrel in the early seventies to $35 in 1981. These years witnessed serious economic crises in industrial and developing economies alike. But despite the burden of higher prices, the role of oil in the world economy continued to grow, and the economic and political influence of the Middle Eastern countries mushroomed.

A third oil era began with the 1979-81 round of price increases. Seemingly overnight, a seller's market became a buyer's market, and prices began to slide for the first time since 1973. Today the world enjoys a large and growing surplus of production capacity. OPEC's share of the market has fallen dramatically, and its ability to influence the price of oil is greatly reduced. Markets for coal, natural gas, and other energy sources have also become more competitive than in the seventies. Oil's role in the world economy is apparently not as immutable as economists once argued and past history indicated. But the third oil era is still not fully defined. Uncertainty grows as prices continue to decline and world oil consumption falls further below the expectations of government and industry analysts.

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When the official OPEC oil price hit $34 in 1981 (as high as $42 in the spot market), most analysts expected prices to continue rising.[3] The first oil crisis in the early seventies had only slightly altered the global trend toward increased oil dependence, and few analysts anticipated that adjustment to the second shock would be any greater. Escalating prices, periodic "crises," and continuing oil dependence were generally anticipated. Hardly anyone suggested that oil markets had reached a watershed that would lead to far-reaching changes.

By 1981, real oil prices (after discounting for inflation) were five times the level of the early seventies. (See Figure 2.) Perhaps as important, people and industries around the world had, by the early eighties, experienced several years of rising oil prices and had begun planning accordingly. The response was overwhelming and persistent. Demand for oil plummeted and prices began to tumble.

The year 1979 probably marked the historical peak in worldwide oil dependence—over ten years earlier than predicted in the mid-seventies by petroleum geologists. Oil consumption is certainly one of the world's key economic indicators, and rarely has such an essential indicator turned around so quickly. By 1983, world oil consumption had shrunk 14 percent, falling to less than 57 million barrels per day. The economic recovery of 1984 boosted oil consumption slightly, but it has recently stagnated at about 58 million barrels daily.

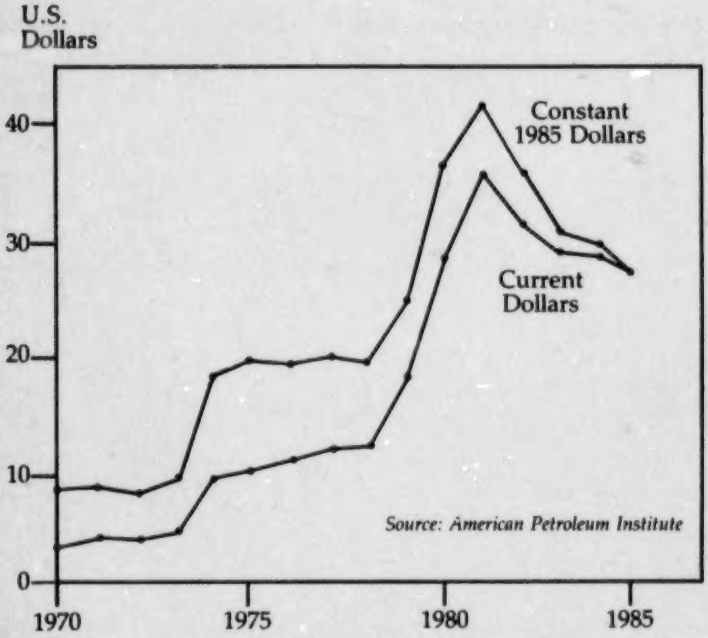

Figure 2: World Oil Prices, 1970-85

Declining oil consumption in the world's industrial countries is the main reason for shifts in world petroleum markets in recent years. In the mid-seventies, Western Europe, North America, and Japan together accounted for two-thirds of world oil consumption. (The United States, with 6 percent of the world's population, consumed 30 percent of its oil.) Between 1979 and 1984, oil consumption declined 18 percent in Western Europe, 16 percent in North America, and 16 percent in Japan. (See Table 1.) Oil consumption per unit of gross national product—a good measure of oil dependence—fell 36 percent

Table 1: World Oil Consumption by Region, 1973, 1979, and 1984

	1973	1979	1984	Change 1979-84
	(million barrels per day)			(percent)
North America	18.6	19.8	16.6	−16
Western Europe	15.2	15.0	12.3	−18
Japan	5.5	5.5	4.6	−16
Soviet Union and Eastern Europe	8.4	11.1	11.4	+ 3
Latin America	3.4	4.2	4.5	+ 7
Other Asia/Oceania	3.9	5.6	5.8	+ 4
Middle East	1.2	1.5	1.9	+27
Africa	1.0	1.4	1.7	+21
Total[1]	57.1	64.1	58.9	− 8

[1]Numbers may not add exactly due to rounding.

Source: *BP Statistical Review of World Energy.*

in the Western industrial countries and Japan between 1973 and 1984.[4]

Oil consumption in the rest of the world actually rose 7 percent between 1979 and 1984, despite the intervening economic recession. Most developing countries are starting at low levels of oil use, have inefficient industrial and transportation systems, and have been unable to afford the investments needed to develop alternative energy sources. Countries with centrally planned economies have also been relatively slow to move away from oil, in part because their economic systems protect industries and consumers from the full brunt of higher oil prices. But even in countries where oil consumption is rising, it is doing so at a much slower rate than in the seventies.

"The Middle East as a whole supplied just 4 percent of the oil consumed in the United States in 1984."

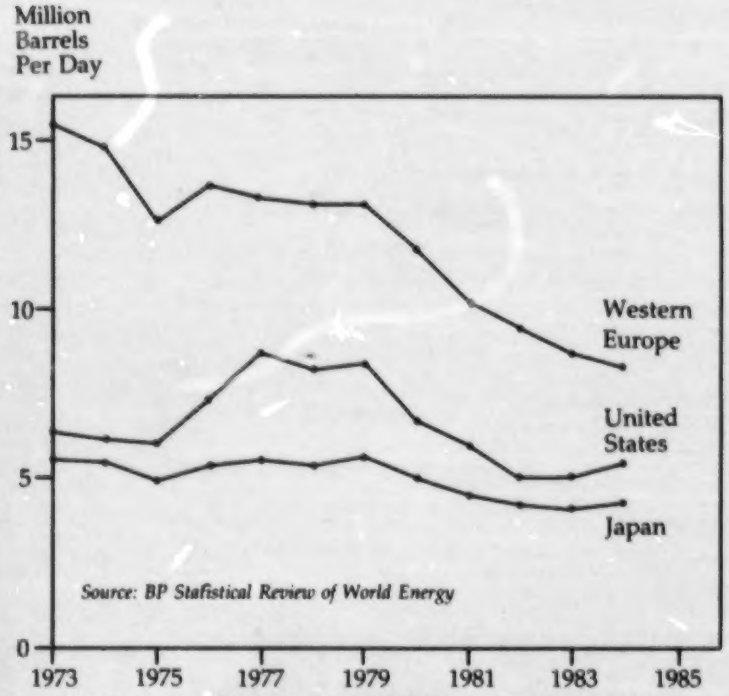

Figure 3: Oil Imports in OECD Countries, 1973-84

Between 1979 and 1984, oil imports fell 34 percent in Western Europe, 40 percent in the United States, and 26 percent in Japan. (See Figure 3.) Together these countries account for over four-fifths of the 31 percent decline in world petroleum trade since 1979. In 1984, the two largest exporters of oil to the United States were the adjacent countries of Canada and Mexico. The Middle East as a whole supplied just 4 percent of the oil consumed in the United States, down from 20 percent in 1979. Japan, on the other hand, still gets two-thirds of its oil from the Middle East.

Table 2: Crude Oil Production By World's 10 Leading Producers, 1973, 1979, and 1984

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	1973	1979	1984	Change 1979-84
	(million barrels per day)			(percent)
Soviet Union	8.7	11.9	12.4	+ 4
United States	11.0	10.1	10.4	+ 3
Saudi Arabia	7.4	9.6	4.7	−51
Mexico	0.6	1.6	3.0	+88
Iran	5.9	3.2	2.5	−22
United Kingdom	0.0	1.7	2.6	+53
China	1.1	2.1	2.3	− 9
Venezuela	3.5	2.4	1.9	−21
Canada	2.1	1.8	1.6	−11
Indonesia	1.3	1.6	1.4	−12

Source: *BP Statistical Review of World Energy.*

Adding to competition in world oil markets is the greater than 5 million barrel per day increase in non-OPEC oil production since 1979. Over half of this rise came from two areas—Mexico and the North Sea. (See Table 2.) Mexican oil production has almost doubled since 1979, adding 1.4 million barrels per day to the oil market. British and Norwegian oil production went from near zero in the early seventies to 3.3 million barrels per day in 1984. These countries have become major oil exporters and important counterweights to OPEC in international markets.

Other nations that have significantly boosted oil production in recent years include Brazil, Colombia, Egypt, Malaysia, and Pakistan. The new oil has provided welcome domestic energy supplies and has improved national trade balances. But it has added only 1.3 million barrels per day to the world oil supply. Much of that is consumed internally. Emerging Third World oil producers have so far had little effect on world oil markets.

"Oil markets today are increasingly competitive, shaped more by market forces than by governmental and corporate decisions."

More important to the emergence of an oil glut are the world's largest producers, the Soviet Union and the United States, which have so far staved off anticipated declines in production. Record levels of oil exploration and drilling caused U.S. oil production to rise 0.3 million barrels per day after falling 1.5 million barrels per day in the seventies. Soviet production rose by 0.5 million barrels per day between 1979 and 1983, defying predictions by Western analysts that Soviet oil production would fall more than 15 percent. Together the two superpowers are producing about 3 million barrels more each day than expected.

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As oil consumption declined and production in non-OPEC countries increased, far reaching changes have been made in the way oil is bought and sold in world markets. Once controlled by a cartel of multinational oil companies and then by OPEC itself, oil markets today are increasingly competitive, shaped more by market forces than by governmental and corporate decisions. Whereas in the seventies, 95 percent of the oil traded internationally was under long-term contract, today 40-50 percent of the oil is sold on spot markets at prevailing prices.[5] Most OPEC countries now sell some of their oil on the spot market, as does the Soviet Union. This brave new world of competition generally appears to be a healthy development in world oil markets, providing flexibility and a cushion for future swings in supply and demand. But until the new arrangements are tested by a future oil crisis, the benefits of a competitive oil market are hard to determine.

The New Geopolitics of Oil

The most surprising development in oil markets is not that consumption has declined or that prices have fallen, but that prices have not collapsed despite large reductions in demand and new supplies of oil—as has happened when similar gluts hit the copper and uranium markets. But the explanation is quite simple: OPEC. Although it has lost the capacity to set world oil prices directly, the cartel has drasti-

cally cut production and given up market share in order to prevent a price collapse.

16 OPEC oil production was reduced from 31 million barrels per day in 1979 to 18 million barrels per day in 1984, and OPEC's share of world oil output fell from 49 to 30 percent. (See Figure 4.) Within OPEC, the decline in production was not evenly borne. Outside the Middle East, Ecuador actually raised oil production. African producers Algeria and

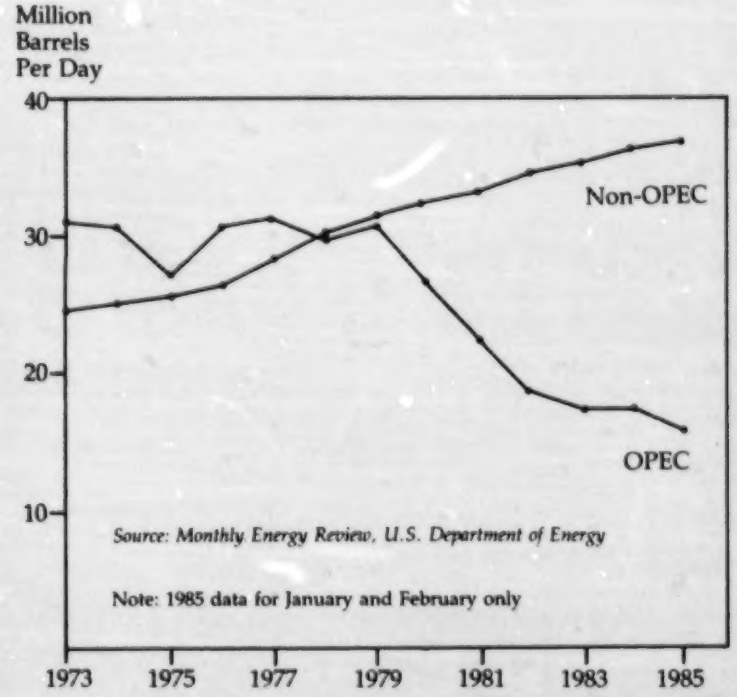

Figure 4: World Oil Production, 1973-85

Nigeria cut production by 23 and 46 percent, but then raised production in 1984 as their foreign debts soared. These and other OPEC countries are believed to be undercutting official prices in order to maintain their market share and prevent further erosion of oil revenues.[6]

The major Middle Eastern oil producers with the bulk of world oil reserves have cut production much further. (See Table 3.) By early 1985, Kuwait's production had declined 60 percent and Libya's was down 50 percent. The Iran-Iraq war has cut oil production in those

Table 3: OPEC Oil Production and Revenues, 1973, 1980, and 1984

	1973	1980	1984	1973	1980	1984
	(million barrels per day)			(billion dollars per year)		
Saudi Arabia	7.4	10.0	4.7	4.3	102.2	44.6
Kuwait	3.0	1.4	1.0	1.8	17.9	10.3
Iraq	2.0	2.6	1.2	1.8	26.1	9.4
Iran	5.9	1.5	2.2	4.4	13.5	19.1
Libya	2.2	1.8	1.1	2.2	22.6	10.9
United Arab Emirates	1.5	1.7	1.2	0.9	19.5	10.8
Algeria	1.1	1.1	1.0	1.0	12.5	5.6
Nigeria	2.0	2.1	1.4	2.1	23.4	10.8
Indonesia	1.3	1.6	1.4	0.2	12.9	9.7
Venezuela	3.5	2.2	1.9	3.0	16.3	13.3
Ecuador, Gabon, and Qatar	0.9	0.8	0.8	0.6	8.0	5.7
OPEC Total[1]	30.8	26.9	17.9	22.5	274.9	150.2
Mexico[2]	0.6	2.2	3.0	—	—	—

[1]Numbers may not add exactly due to rounding. [2]Mexico is an ex-officio member.
Sources: *Petroleum Intelligence Weekly* and *BP Statistical Review of Energy*.

two countries by more than 3 million barrels per day, or 50 percent. Ironically, a war between member countries has strengthened OPEC cohesiveness by keeping oil off the market that otherwise would have further undermined prices. Saudi Arabia remains the dominant "swing producer," however, since it has propped up oil prices by removing as much as 7 million barrels per day from the world oil market. Saudi Arabia's oil production fell from 10 million barrels per day in 1980 to 4.7 million barrels in 1984, and as low as 2.5 million barrels in the first half of 1985—the lowest level in 18 years.[7]

While OPEC has proved to be a successful cartel—at least so far—it has paid a price in declining economic growth and a diminished role in the world economy. From a peak of $275 billion in 1981, total OPEC revenues fell to about $150 billion in 1984. A study by the Oxford Institute for Energy Studies in Great Britain shows that due to a decline in demand and price, Arab oil producers lost close to $200 billion in oil revenues between 1982 and 1984. While few people are ready to shed tears for OPEC, this is a real economic crisis for countries that get 95-100 percent of their foreign exchange from oil revenues and that have based government spending programs on now discredited oil revenue projections.[8]

Some oil exporters such as Nigeria, Venezuela, and Mexico—an ex-officio OPEC member—are debtor nations and face a rising tide of economic troubles as oil prices fall. Government leaders made an emergency $1.25 billion cut in Mexico's budget in mid-1985. Even wealthy Persian Gulf oil producers have been dipping into cash reserves since 1982, which has helped tighten international financial markets and kept interest rates high. Saudi Arabia's annual oil revenues have fallen from $113 billion in 1981 to a projected $31 billion in 1985. Saudi Arabia's foreign exchange holdings have fallen from $150 billion to less than $100 billion, and industrialization programs are being trimmed to stem the hemorrhage of capital.[9]

The big winner from the shift in oil markets is the U.S. economy, which has benfited both from declining oil prices and a 40 percent drop in U.S. imports since 1979. The growing U.S. trade imbalance would have been far worse if not for a sharp fall in the oil import bill, from $61 billion in 1981 to an estimated $32 billion in 1985. Oil will

"Saudi Arabia's annual oil revenues have fallen from $113 billion in 1981 to a projected $31 billion in 1985."

account for less than 15 percent of U.S. imports in 1985, down from 34 percent in 1980. Falling oil prices have helped cut U.S. inflation to a 4 percent annual rate, its lowest level in more than a decade. Economists believe that lower oil prices contributed to the record-breaking economic recovery that culminated in a GNP growth rate of 6.8 percent in 1984. A study by Data Resources, Inc. and *Fortune* Magazine concludes that a further drop in world oil prices to $25 per barrel would add 0.4 percent to GNP growth in 1985, and a fall to $20 would add 0.8 percent.[10]

Other economies have benefited far less from the stimulative effect of falling oil prices. This is because most oil is traded internationally in U.S. dollars, and the value of the dollar in relation to most other currencies rose steadily in the early eighties. (The dollar value of the Japanese yen has declined 13 percent since 1981 and the French franc has fallen 44 percent.) While the price of oil has declined 23 percent in U.S. dollars, its cost in Japan has declined just 11 percent. In West Germany the real cost of oil has risen 7 percent, in India it has risen 11 percent, and in France it has risen 38 percent.[11] (See Figure 5.)

The average price of petroleum products in Europe has remained steady since 1981. These high prices have hurt economic recovery and made it more difficult to bring down inflation. Since OPEC countries import large quantities of goods and services from Europe, they have benefited from the strong dollar, which boosts the real value of their oil sales. Consistently high oil prices also account for the continued weakness of oil markets in Europe. The World Bank estimates that oil imports in Western Europe would have been 1.7 million barrels per day higher if exchange rates had remained at the 1979 level.[12]

After falling 20 percent between 1979 and 1983, European oil consumption leveled off in 1984 and declined in early 1985. The current price of oil serves as ample incentive for investments in improved efficiency and, where possible, conversion to other sources of energy. The high value of the dollar also adds uncertainty to European energy forecasts, which now generally include caveats about future exchange rates. A sudden decline in the value of the dollar might undermine billions of dollars worth of energy-related investments and slow Europe's move away from its still heavy reliance on imported oil.

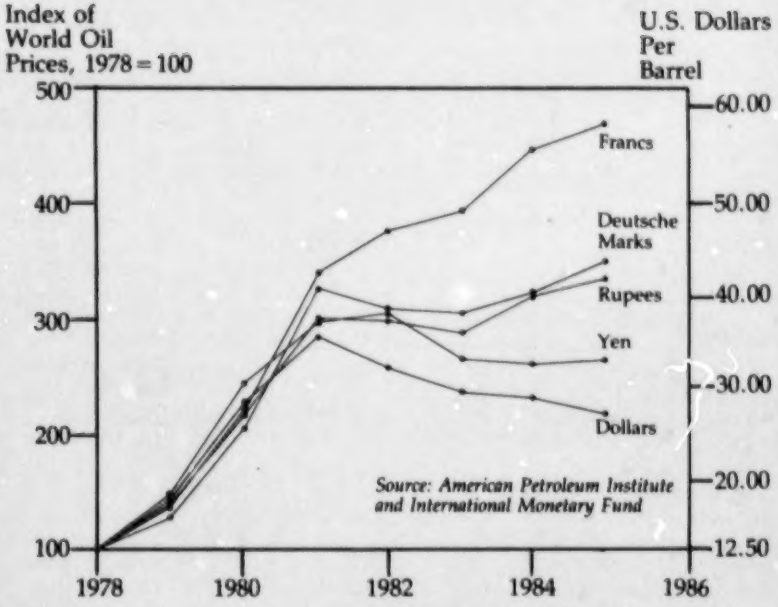

Figure 5: World Price of Oil in Various Currencies, 1978-85

Once largely isolated from world oil markets, the Soviet Union and Eastern Europe are now integral if slightly independent players. Soviet energy planners closely follow OPEC meetings and shifts in international exchange rates, and Western analysts scrutinize Soviet oil industry trends, which can have a major influence on world oil prices. Soviet oil exports to Western countries of about 1.5 million barrels per day are traded competitively on international markets, much the way British or Persian Gulf oil is.

Eastern Europe, with the exception of Romania, has little domestic oil and depends on the Soviet Union for 90 percent of its supplies—close to 2 million barrels per day. But unlike sales to the West, Soviet oil sales to its Eastern European allies are based on a special pricing formula tied to a five-year sliding average of world prices. This formula protected Eastern Europe from the full brunt of oil price increases in the early eighties, but recently prices have pushed upward and are now equal to or slightly above world market prices. The burden of spending about $20 billion a year on Soviet oil is a major strain for the struggling economies of Eastern Europe.[13]

The Soviet Union, with a total output of over 12 million barrels per day, or three-quarters of recent OPEC production, is the world's largest oil producer and a major player in world energy markets. Higher oil prices have boosted the Soviet economy significantly, providing 60-75 percent of its Western "hard currency" earnings in recent years and giving it additional leverage over Eastern European allies. The Soviet Union is potentially a major loser in an era of declining world oil prices, particularly since the price of its large and growing exports of natural gas is linked to world oil prices.[14]

Even more than Europe, Third World countries have failed to reap the benefits of lower oil prices. Accumulating debts and deliberate government policies have accelerated the decline of Third World currencies relative to the dollar. Steady erosion in the markets for commodities such as copper and sugar are an additional burden, since export of these goods finances oil imports. Overall, oil imports absorb a large share of the foreign exchange available to most developing countries—as high as 80 percent in some nations. For many the share has remained unchanged since 1981. (See Table 4.)

Developing countries that have expanded indigenous energy sources or that have rapidly industrializing economies have fared the best. Brazil's hydropower, alcohol fuels, and oil exploration programs have helped lower the country's still staggering oil import bill, and South Korea's expanding supply of coal and nuclear power has done the same. But these large energy investments have themselves created large debts. (In Brazil, one-fifth of the country's foreign debt can be attributed to power plant construction.) The World Bank reports that

Table 4: Energy Imports as a Share of Merchandise Exports in Selected Developing Countries, 1981 and 1983

22

	1981	1983
	(percent)	
Bangladesh	17	20
Brazil	52	56
Colombia	25	21
Costa Rica	21	22
El Salvador	27	57
Philippines	45	44
Senegal	77	58
South Korea	37	28
Sri Lanka	45	40
Sudan	44	57
Thailand	43	39
Turkey	83	66

Source: World Bank, *World Development Report.*

Third World energy investments will absorb about 4 percent of GNP in coming years and will act as a constraint on other industrial investments.[15]

Developing countries with struggling economies have been virtually priced out of the world oil market. According to the World Bank, Africa, with the exception of Nigeria, has barely enough oil to cover essential needs. Some developing countries must take extraordinary measures to pay for oil imports. Cuba reportedly sells sugar to the Soviet Union at ten times the world price and uses the proceeds to buy Soviet oil, part of which it resells on the world market to earn hard currency. In early 1985, amid political turmoil in Sudan, the United States quickly channeled $40 million to the country—to make emergency oil purchases.[16]

"Since the mid-seventies, global proven reserves have increased only 5 percent."

In some Third World countries, transportation systems, factories, and power plants are occasionally shut down when oil supplies run out. Many nations have begun to cut back on their traditionally heavy subsidies for kerosene and diesel fuel, often at the insistence of the International Monetary Fund. The price of petroleum fuels has risen three-to-fourfold in many developing countries since 1981. Rising kerosene prices have led to riots in some countries. The World Bank nonetheless projects that oil consumption in Third World countries will rise 50 percent between 1980 and 1995, making them central in the world oil outlook.[17]

The decline in world oil prices has on balance benefited the world economy, but these benefits are unevenly spread, and some of the neediest countries have been left out entirely. More than perhaps any other market, the oil market has become truly global in scale, linking economies with vastly different economic systems and income levels. Whatever the direction of oil trends, virtually all countries have a major stake in their future.

The Limits to World Oil

The standard measure of world oil resources is proven reserves. Included in this category is oil found in known reservoirs but not yet produced. Each year the oil discovered is added to proven reserves, and the oil "produced" is subtracted. Global proven oil reserves increased rapidly throughout the postwar period—rising from 76 billion barrels in 1950 to 664 billion barrels in 1973.[18] But since the mid-seventies, global proven reserves have increased only 5 percent, even as higher oil prices have encouraged exploration and annual oil extraction has declined. (See Figure 6.) The bottom of the oil barrel is now visible, marking a major milestone in the petroleum age.

Additions to world oil reserves after mid-century came principally from the Middle East, where oil reservoirs vastly larger than those found in other parts of the world were discovered. Between 1970 and 1977, global reserve figures were sustained by more modest additions in the Middle East and major discoveries in Alaska, the North Sea, and Mexico. But since the late seventies, annual additions to oil

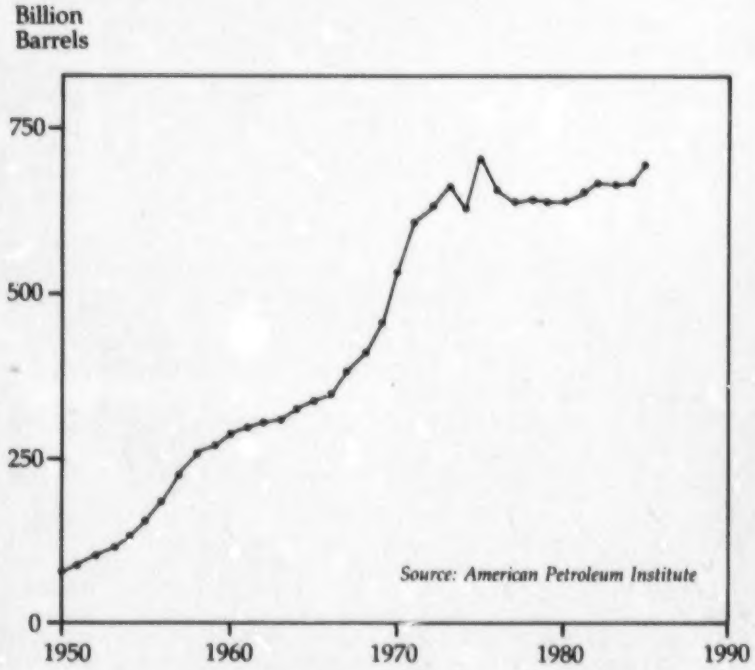

Figure 6: World Proven Oil Reserves, 1950-85

reserves have sometimes not even been sufficient to replace the oil extracted. Recent reserve additions result mainly from continued exploration of already established reservoirs in major oil producing regions.

Estimating the ultimate size of world oil resources is obviously far more difficult than determining proven reserves. However, the ability to predict oil availability has improved enormously in the past few

decades, due to advances in petroleum geology as well as extensive drilling throughout the world. Such advances, together with the discovery of the unprecedented size of Middle Eastern oil deposits, led geologists to greatly raise their estimates of world oil resources between the mid-forties and mid-sixties. Since the mid-sixties, however, estimates have stabilized and their range has gradually narrowed. Indeed, the most authoritative oil resource estimates are slightly lower than those made in the mid-seventies.[19]

A range of 1,600 to 2,400 billion barrels encompasses all but the most extreme oil resource estimates of the mid-eighties.[20] Of this total, 554 billion barrels have already been consumed; 700 additional billion barrels of proven reserves have been discovered. This leaves a range of between 350 and 1,150 billion barrels of oil remaining to be discovered. About 21 billion barrels are being extracted each year. At the 1985 rate of consumption, the ultimate depletion of world oil resources is between 50 and 88 years away. Little of the world's petroleum is likely to remain by the bicentennial of the world's first oil well in the year 2059.

How much faith can be placed in these global reserve figures? Scientific advances and extensive exploration during the past decade have provided important evidence with which to make such estimates. Geologists have found that the occurrence of exploitable oil deposits is rare, confined to areas where a coincidence of geological events caused oil to be formed, trapped, and preserved for millions of years. Geologists can now rule out many areas as potential oil producers, based on surface geology or on seismic studies. But the likelihood of finding oil in "promising" areas is still difficult to predict. Oil fields in Mexico have substantially more oil than initially expected, but other promising areas, such as the Atlantic Coast of the United States, have turned up virtually nothing.

More than three-quarters of the world's sedimentary areas have been explored, and results confirm a key hypothesis on which oil resource estimates are based: almost 90 percent of the world's oil is found in just 25 of the world's 600 identified sedimentary "provinces" or regions. Given their geology, such provinces are easy to target as potential oil producers, and within them oil is concentrated in large

fields that are found quickly. Over two-thirds of the oil discovered so far is in just seven "giant provinces." Almost half is in the world's only "mega-province"—located in the Middle East. Once the large early finds are made, discoveries tend to drop off quickly. Richard Nehring of the Rand Corporation believes that only about 10 percent of the world's oil lies in small or very small fields.[21]

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The largest oil discoveries of the seventies—in Alaska, the North Sea, and Mexico—have added significantly to the world's inventory of proven reserves. By historical standards, however, these discoveries are modest in size and so have added little to estimates of ultimately recoverable reserves. Even before this oil was discovered, analysts assumed that such quantities would be found, although they were not sure exactly where.

Some analysts justify more optimistic assessments of world oil resources by noting that higher prices will encourage greater oil exploration and more thorough recovery of known deposits. But the estimates described above include assumptions that prices will rise and technologies will improve. Enhanced oil recovery using water or steam injection has begun in some areas, stimulated by recent price increases. Even the lower resource estimates assume that enhanced recovery will become standard practice in the decades ahead. (Petroleum geologists generally agree that it will never be economical to extract much more than half the oil in a given field; beyond that, costs become prohibitive.)

Nehring of the Rand Corporation summed up the view of many petroleum geologists in 1982:

> . . . the consensus view of ultimate conventional world oil resources is justifiable. Specifically, the lower half of the consensus range (1600-2000 billion barrels) is most likely to be correct. Ultimate oil resources are likely to be in the upper half of the range (2000-2400 billion barrels) only if there are one or more major breakthroughs in oil recovery technology. Conversely, the alternative high estimates are, to put it bluntly, nonsense. Appearing as mirages rising from the deserts of abstract reasoning,

"In 1985, U.S. proven reserves reached their lowest level since 1951."

> they distract from and are oblivious to the wealth of publicly available concrete information on world oil occurrence, the conditions determining it, and the specific remaining geologic and engineering possibilities.[22]

A 1983 study by scientists at the U.S. Geological Survey (USGS) reaches similar conclusions, including a mid-range estimate of ultimate reserves of just 1,700 billion barrels. The USGS scientists note that,

> Demonstrated reserves of crude oil have declined over the past 10 years consistent with discoveries lagging production over the same period . . . Rates of discovery have continued to decline over the past 20 years even though exploration activity has increased in recent years. Prudence dictates, therefore, that the low side of the assessment of undiscovered resources be responsibly considered . . . [23]

As important as the ultimate size of world oil resources is their location. Here, too, the concentration of oil in large provinces is key. About 56 percent of the world's proven oil reserves and 23 percent of estimated undiscovered reserves are in the Middle East. (See Figure 7.) Overall, 95 percent of proven reserves are in just 20 countries. Oil remains one of the world's most unequally distributed resources.[24]

The United States is the world's second largest oil producer and the most intensively explored country in the world. Oil production in the continental United States peaked in 1970 at over 9 million barrels per day and fell to 7 million barrels per day in 1980. When higher oil prices and price decontrols caused a surge in U.S. petroleum exploration and secondary recovery, the decline in U.S. oil production was halted temporarily. However, the reserve/production ratio, a key measure of oil resources, has continued to fall, and in 1985 U.S. proven reserves reached their lowest level since 1951. Independent analyst John Lichtblau of the Petroleum Industry Research Foundation writes, "In effect, most of these activities [accelerated drilling and enhanced recovery] have been a form of current production maximization by borrowing from the future."[25]

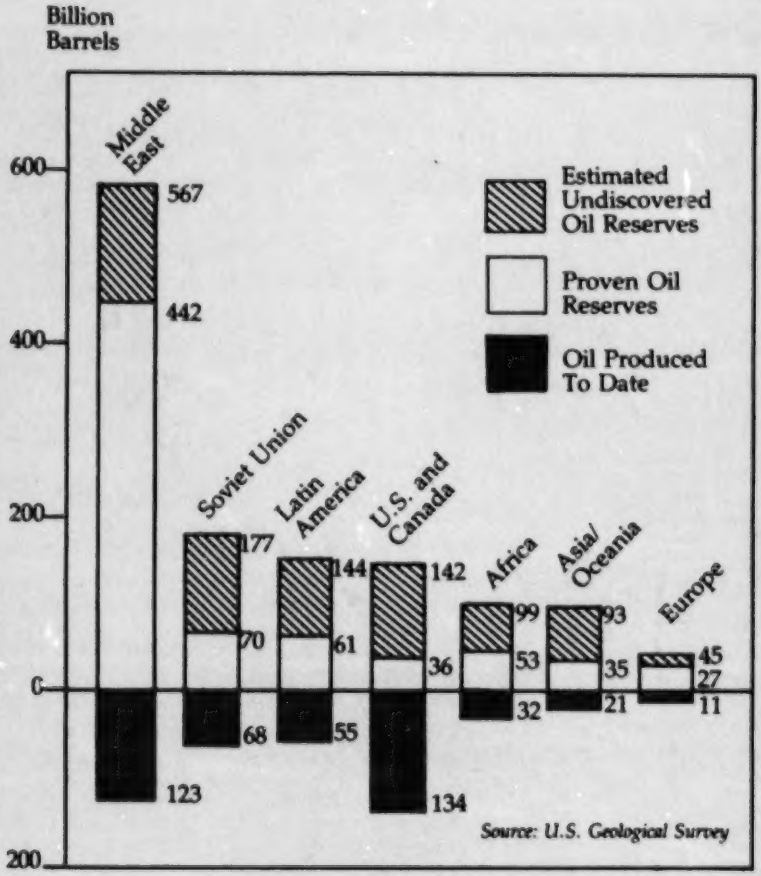

Figure 7: World Oil Reserves and Cumulative Production by Region, 1984

In recent years, the U.S. oil industry has increasingly turned to offshore oil, which was given a big boost by the Reagan administration's program of accelerated leasing of offshore oil tracts. Unsuccessful exploratory drilling, however, has already dashed some of the more grandiose hopes, and in early 1985 the U.S. Geological Survey (USGS) reduced its estimate of undiscovered offshore oil by 55 percent. This reduction lowers estimated undiscovered U.S. oil resources by 18 percent, or five years of production at current rates.[26]

A six-year, $3 billion exploration of the Atlantic continental shelf yielded mainly dry wells and no exploitable oil. USGS estimates for the region have been lowered 87 percent. In Alaska's Beaufort Sea, where operating costs are high and oil finds must be large to be economical, a consortium of companies spent $1.5 billion on a single offshore field called Mukluk that turned out to be dry. Other fields in the Beaufort Sea have turned up some oil, and companies are hopeful that future searches will be successful. But overall, reserve estimates for offshore Alaska were lowered 73 percent. On the other hand, the continental shelf of the Gulf Coast has become a major petroleum producer and reserve estimates have not changed. The Pacific Coast is still a question mark, with several successful discoveries, some disappointments, and environmental conflicts clouding most efforts.[27]

The U.S. oil outlook continues to be dominated by the large and already heavily exploited fields in the Southwest, along the Gulf Coast, and Alaska's North Slope. The consensus forecast among both industry and non-industry analysts is that the long-term decline in U.S. oil production will soon resume. Reserve additions simply have not been sufficient to maintain current levels of production for very long, and the boost given to the oil industry by higher world prices and price decontrol is beginning to fade. Production from Alaska's North Slope fields, which has provided one-fifth of U.S. oil in recent years, offsetting declines in the lower 48 states, has leveled off at 1.7 million barrels per day. Alaskan state officials project that North Slope oil production will fall beginning in 1990. Overall, a reduction of a half million to one million barrels per day in U.S. oil production is likely by 1990, and a 1.5-3 million barrel decrease is likely by the year 2000. Falling prices and retrenchment by the oil industry could accelerate the decline in U.S. oil production.[28]

The Soviet Union, the world's largest oil producer at 12.5 million barrels per day, is also one of the largest question marks. The oil industry is a high priority of the Soviet government, and, as in the West, Soviet investments in oil rose during the early eighties. Oil drilling increased from 50 million feet of wells in 1979 to 90 million feet in 1984, and production rose by more than a half million barrels per day. Reserve additions have come relatively slowly in recent years, however, and in 1984 and early 1985, Soviet oil production declined for the first time since World War II.[29]

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The Soviet Union is heavily dependent on relatively old and declining oil fields and is plagued by difficulties in opening up new production frontiers. The key producing area of Tyumen in West Siberia, which provides 63 percent of Soviet oil, has fallen below official targets for the past three years, and many fields are producing as much water as oil. The Soviet government blames some of these problems on poor management of the Soviet oil industry, and a 1985 shakeup resulted in the ouster of the country's oil minister. But Western analysts believe that with limited reserves and the 1984 drop in production, the inevitable can no longer be postponed. Since the Soviet Union now produces more than one-fifth of the world's oil, any significant decline in Soviet production will have a major effect on oil markets worldwide.[30]

North Sea oil is one of the largest and most welcome additions to world supplies in recent years. Oil production by North Sea producers Britain, Denmark, and Norway reached 3.3 million barrels per day in 1984, greatly easing Europe's dependence on imported petroleum. Exploration and development efforts are booming in the North Sea, but reserve additions have been modest in recent years as companies turn to fields that are much smaller than those developed initially. Some North Sea oil fields have exploration and development costs as high as $20 per barrel, among the highest in the world. Industry officials believe that an additional $2 decline in the world price of oil could make a number of North Sea projects uneconomical. Even without further price decreases, North Sea oil production is projected to peak before 1990 and decline steadily during the nineties.[31]

"At the U.S. rate of per capita oil consumption, China's reserves would be gone in 10 months."

Mexico has also added to world oil supplies. Production grew steadily in the late seventies, reached 3 million barrels per day in 1982, and has stayed at about that level due to weak demand and a government decision to produce at less than capacity. Mexico's oil resources were developed relatively late, and its proven reserves of 48 billion barrels are 40 percent higher than those of the United States. Worldwide, only Saudi Arabia, Kuwait, and the Soviet Union have more oil than Mexico does. Some analysts believe that Mexico could add as much as one million barrels per day to the world oil supply before production peaks in the mid-nineties. However, rapid growth in Mexico's internal oil requirements will probably keep Mexico from ever exporting much more than the current 1.5 million barrels per day. Unless the Mexican government takes action to restrict oil consumption, the country could easily become a net importer by the year 2000.[32]

China is another key country in the world oil equation. Oil production in China grew significantly during the fifties and sixties, but then leveled off at about 2 million barrels per day in the late seventies as fields were exhausted and discoveries lagged in the major producing region south of Beijing. Since then, major efforts have been launched to open new oil fields, particularly offshore in the South China Sea and the Bohai Gulf. Contracts signed with over 30 Western and Japanese oil companies in the early eighties are expected to result in billions of dollars worth of exploration.[33]

No sizable oil reserves have been found so far, and most companies have given up hope that China will one day be a major oil exporter. Many promising areas remain to be drilled, however, and the government has redoubled its efforts, including inviting multinational companies to explore in western China for the first time. Oil is important to China's ambitious modernization program, and major oil finds will be necessary simply to maintain the current production level. China's remaining petroleum reserves of 19 billion barrels equal only 19 barrels per person. At the U.S. rate of per capita oil consumption, China's oil reserves would be gone in 10 months. Incredibly, in order to earn precious foreign exchange (oil provides 15-20 percent of the country's hard currency earnings), China has managed to remain an exporter of about one million barrels of oil per day. This leaves just

one-third of a barrel of oil per capita to be used each year domestically. The World Bank believes that China may eventually be forced to stop exporting oil altogether.[34]

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Petroleum exploration was started or stepped up in at least 30 additional countries during the past five years. Many of these efforts involve Third World governments, multinational corporations, and financial assistance from Western banks or multilateral organizations such as the World Bank. The biggest success stories are in Colombia, where oil production is expected to reach 400,000 barrels per day by 1987, and Brazil, which has similar potential. Other countries with smaller oil discoveries include Angola, Argentina, Australia, Cameroon, Egypt, India, Malaysia, Pakistan, Peru, Syria, and Zaire. Thanks to exploration efforts stimulated by the oil price increases of the seventies, these countries have the potential to one day become self-sufficient in oil.[35]

These recent discoveries have increased global oil reserves less than 1 percent, however, and at their peak they will provide only an additional 1-2 million barrels per day of oil. John Lichtblau concludes, "Production increases can of course be expected from a number of other non-OPEC countries, such as Egypt, Brazil, Colombia, India, and West African countries. But there is nothing in sight which would compare even remotely with the developments of the 1970's."[36] Most developing countries remain desperately short of oil.

Rising production of non-OPEC oil has added 5 million barrels per day to the world oil supply and played a major role in the oil glut. But despite this recent boost, the long-term oil outlook remains dominated by Middle Eastern members of OPEC that have 56 percent of the world's oil. In fact, recent shifts in world oil markets have some rather disturbing long-term implications: the rate of depletion of the world's most abundant oil resources has slowed, while depletion of some of the scarcest and most strategically important reserves has accelerated. At the 1984 extraction rate, U.S. proven oil reserves will last only about nine years. (See Table 5.) Saudi Arabia's oil reserves, on the other hand, would last almost 100 years at the 1984 rate of extraction. Charles Ebinger, an energy analyst at Georgetown University's Center for Strategic and International Studies, believes that

"Depletion of some of the scarcest and most strategically important reserves has accelerated."

Table 5: Oil Production, Reserves, and Reserves/Production Ratios for the World's Major Oil Producing Nations, 1984

	Annual Production	Reserves	Reserves/Production
	(billion barrels)		(ratio)
Kuwait	0.36	90.0	250
Iraq	0.43	44.5	104
Saudi Arabia	1.71	169.0	99
United Arab Emirates	0.44	31.9	73
Iran	0.80	48.5	61
Libya	0.40	21.1	52
Mexico	1.10	48.6	45
Venezuela	0.68	25.8	38
Nigeria	0.51	16.7	33
United Kingdom	0.94	13.6	14
Soviet Union	4.53	63.0	14
United States	3.79	34.5	9
World Total	21.10	707.2	34

Source: *BP Statistical Review of World Energy.*

OPEC's share of the world oil market will reach 55 percent in the nineties, up from 27 percent in 1985.[37]

Even within OPEC, several countries with limited reserves are now producing at near maximum capacity in order to sustain their economies, while Persian Gulf countries with the largest reserves are restricting production in order to support OPEC prices. During the nineties, oil production is almost certain to decline in such OPEC countries as Algeria, Ecuador, Gabon, Indonesia, and Nigeria. None is likely to remain an oil exporter past the mid-nineties. During the next ten years, OPEC may well become a smaller, more geographically concentrated, more cohesive, and more powerful organization.[38]

Non-Middle Eastern oil production is approaching its peak. By 1990, at the latest, declining oil production in the United States, the Soviet Union, and Great Britain will greatly outweigh increases in such countries as Brazil, Colombia, and Mexico.[39] These trends should raise warning flags for anyone tempted to celebrate the demise of the Persian Gulf oil producers. Growing independence from Middle Eastern oil provides a false sense of security since it has occurred largely at the expense of greater long-term dependence. The lower the current Middle Eastern share of the market, the greater its share at the end of the century when many countries will be running out of oil. The danger is that the Persian Gulf may move back into the driver's seat at a time when world oil resources are more limited than at any time in recent history.

Energy Efficiency and New Energy Sources

Although new oil supplies and economic recession have contributed to the oil glut, the development of energy alternatives has contributed far more. Data for the Western industrial countries show oil consumption per unit of economic output falling 36 percent between 1973 and 1984.[40] Improved energy efficiency accounts for just over half of this drop, and the substitution of other energy sources accounts for the other half. The use of coal, natural gas, nuclear power, and renewable energy sources has increased greatly since the seventies. Oil's share of world energy use has fallen from 41 to 35 percent and continues to decline. (See Table 6.)

Since 1973, unprecedented investments have been made in mining, transporting, and burning coal. Global coal consumption increased by the equivalent of 10 million barrels of oil per day by 1984. (See Table 7.) Much of the increase has gone to fuel new power plants and factories, mainly where coal is already heavily used, such as the United States, the Soviet Union, Europe, and Australia. The greatest increase in coal consumption was a 50 percent rise in China, which is now the world's largest user, deriving 80 percent of its commercial energy from coal. China is husbanding its limited oil reserves for

Table 6: World Energy Use by Source, 1973, 1978 and 1984[1]

	1973		1978		1984	
	(amount)	(percent)	(amount)	(percent)	(amount)	(percent)
Oil	56.0	41	61.6	41	57.1	35
Natural Gas	21.3	16	24.1	16	28.3	17
Coal	33.4	25	37.3	25	43.8	27
Renewables	23.5	17	25.8	17	28.7	18
Nuclear	1.0	1	3.0	2	5.7	3
Total[2]	135.2	100	151.8	100	163.6	100

[1]In terms of million barrels per day of oil equivalent. [2]Percentage totals do not equal 100 due to rounding.

Source: *BP Statistical Review of World Energy;* Openshaw, "Woodfuel—A Time for Reassessment."

export by using coal as the chief fuel of its modernization program. Overall, coal's share of world energy use has risen from 25 percent in 1978 to 27 percent in 1984.[41]

Coal is by far the world's most abundant fossil fuel, and many analysts predict that it will eventually replace oil. The World Coal Study, conducted by an international team of energy experts in the late seventies, projected that world coal production would grow at a 4.5 percent annual rate, almost tripling between 1977 and 2000. A global energy study conducted by the International Institute for Applied Systems Analysis projected that coal would be the largest contributor to world energy supplies during the next 50 years.[42]

During the past decade, however, coal use has grown at less than a 3 percent annual rate and signs point to slowdowns in the years ahead. European coal markets are glutted, mines are being closed, and jobs lost. U.S. coal production, which rose 40 percent in the past decade, is falling in 1985. Signs indicate that the decade-long U.S. coal boom is coming to an end. U.S. coal prices are falling for the first time in a decade, and existing contracts are being renegotiated to reflect the

Table 7: World Coal Consumption, 1973, 1978, and 1984

	1973	1978	1984
	(million barrels of daily oil equivalent)		
China	5.8	7.6	9.4
Soviet Union	6.3	6.9	7.2
United States	6.7	7.0	8.7
Western Europe	5.1	4.9	5.2
Other	9.4	10.9	13.3
Total[1]	33.4	37.3	43.8

[1]Numbers may not add exactly due to rounding.

Source: *BP Statistical Review of World Energy.*

changed market outlook. Many companies have overinvested in coal, and the high cost of mining, transporting, and burning coal with the needed pollution controls has cut into its growth.[43]

The only major growth market for coal in recent years has been in power generation, but orders for new coal-fired power plants in Europe and North America have come to a near standstill since 1980, heralding a sluggish coal market in the late eighties. Industry is using much less coal than predicted. In the United States, industrial use of coal declined 19 percent between 1979 and 1984. The most rapid growth in coal use is likely to occur in developing countries with abundant supplies, including China, Colombia, and India. But most developing countries do not have much coal and are unlikely to make the large investments needed to import and use coal.[44]

Coal will have an increasingly difficult time finding new uses. Synthetic fuels, heralded in 1980 as the energy source of the future, will have little chance for economic viability or political support amid steady or declining oil prices. Billions of dollars worth of synthetic fuels projects have been canceled in the past decade, and the U.S. Congress is now studying whether to abolish the government-funded Synthetic Fuels Corporation. The companies that built the largest

surviving U.S. facility, the Great Plains coal gasification plant, threaten to shut it down unless they receive price supports equivalent to $100 per barrel. Only a handful of synthetic fuels projects are still under way. Most are government-funded projects in Japan, the United States, and West Germany.[45]

The largest cloud hanging over coal is environmental. Acid rain, caused at least in part by the sulfur dioxide emitted by power plants, has damaged one-half of West Germany's forests and has led to serious controversy over whether to operate already completed coal-fired power plants. Growing evidence of acid rain damage throughout Europe and North America, combined with concern over future regulations and the cost of pollution control technologies, has contributed to a slowdown in the construction of coal plants. New coal-burning technologies such as fluidized bed combustion are developing quickly, but their widespread use is at least a decade away. Moreover, policymakers have yet to address coal's ultimate environmental problem: the release of carbon dioxide on a scale that will eventually alter the earth's climate. If evidence of an actual warming of the climate should be detected in the next decade, as climatologists predict, a worldwide effort to lower coal consumption may be necessary.

World use of natural gas rose from 21 million barrels per day of oil equivalent in 1973 to 28 million barrels in 1984, raising its share of the global energy supply to 17 percent. (See Table 8.)[47] But these figures understate the expanding role of gas throughout much of the world. Natural gas consumption fell steadily in the United States during the seventies due to rising prices and temporary shortages caused by price controls. But in the rest of the world gas use jumped 90 percent.

Natural gas is the only fossil fuel for which reserve estimates have risen significantly—34 percent in a decade. Proven worldwide reserves in 1985 stood at 3.4 quadrillion cubic feet, equivalent to 590 billion barrels of oil. The world has about 700 billion barrels of proven oil reserves. Natural gas reserves are only 15 percent lower than oil reserves, but natural gas now supplies just half as much energy.

Table 8: World Natural Gas Consumption, 1973, 1978, and 1984

	1973	1978	1984
	(million barrels of daily oil equivalent)		
North America	11.2	10.0	9.0
Soviet Union	4.0	5.8	8.8
Western Europe	2.6	3.5	3.9
Other	3.5	4.8	6.6
Total	21.3	24.1	28.3

Source: *BP Statistical Review of World Energy.*

Before the seventies, natural gas was largely unexploited outside North America and Europe. Natural gas is not heavily traded internationally, and countries lacking the facilities to process, transport, and use natural gas had little incentive to develop the resource when oil prices were low. Indeed, in the major oil exporting countries, large quantities of gas found in association with oil were flared off as an unusable byproduct. In the Middle East alone, the equivalent of at least 4 billion barrels of oil have been flared since 1973.

Today, Middle Eastern countries, as well as such oil exporters as Indonesia and Mexico, are investing large sums in gas processing equipment and gas-using industries. Only 51 percent of the gas extracted in the Middle East was flared off in 1982, down from 70 percent in 1972, and this figure is projected to fall to as low as 10 percent by 1990. Natural-gas-based petrochemical plants are becoming important parts of the economies of most petroleum exporters. Productive use of natural gas in the Middle East rose 38 percent between 1972 and 1982.[48]

Large gas discoveries in the Soviet Union rank as one of the big energy success stories of the past decade. The Soviet Union now has gas reserves with the energy equivalent of 250 billion barrels of oil, or more than ten years worth of world oil consumption. The Soviet

"Most governments have underestimated the potential contribution of natural gas."

Union is not just the Saudi Arabia of natural gas; its 43 percent share of world gas reserves is closer to the entire Middle East's 56 percent share of world oil reserves. Soviet gas consumption doubled during the past decade, providing energy for industry, power plants, and households, and helped prevent a decline in oil exports.

In the past five years, several countries have invested in facilities for exporting natural gas, mainly via pipelines. Canadian gas is now exported to the United States, and additional pipelines are planned. Similarly, Europe is turning to Algeria and the Soviet Union to supply it with natural gas. Liquefying natural gas for export is a much more hazardous and expensive process, but facilities are being built in Indonesia and New Zealand in order to export gas to Japan.[49]

Although global gas reserves are even more geographically concentrated than oil reserves, over 30 oil importing developing countries have recently found enough gas to improve their energy situations significantly. The oil importing developing countries with the largest gas reserves are Argentina, Bangladesh, India, Malaysia, Pakistan, Thailand, and Trinidad and Tobago. In Bangladesh, Pakistan, and Thailand, natural gas may meet over half of additional energy needs during the next decade.[50]

World Bank energy planners believe that in much of the Third World, natural gas will be a more important domestic energy source than oil, and that gas development should be made an investment priority. In most of the countries surveyed, domestic natural gas will cost between $2 and $12 per barrel of oil equivalent, including infrastructure costs. This is far less than the cost of imported petroleum products, even if the world oil price should decline a good deal further. In 1985, the World Bank plans to loan about $300 million for natural gas development, compared to $400 million for oil projects. Overall, natural gas use in developing countries is projected to quadruple between 1980 and 1995. Since most of this gas will replace oil in industry and power generation, it will help lower the oil import bills of many countries.[51]

Evidence is mounting that most governments have underestimated the potential contribution of natural gas. Even in Europe and North

America, a combination of neglect by oil companies and government price controls has kept gas use far below its potential. In Europe, official projections still call for declining gas production, but private analysts believe the recent lifting of government restrictions will cause a 60 percent rise by the year 2000, which together with gas imports would compose 27 percent of Europe's energy supply. In the United States, a 1985 study by the Congressional Office of Technology Assessment suggested that gas resources were probably large enough to maintain the current rate of use for several decades, a sharp departure from earlier projections that gas use would inevitably decline in the years ahead.[52]

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More intensive exploration in remote areas, increased investment in Third World gas, and the gradual development of promising "unconventional" gas resources, including very deep gas and gas found in tight formations, Devonian shale, and coal seams, is likely to keep world gas use on a steady growth curve. A profusion of efficient gas technologies are now being developed, including furnaces, air conditioners, industrial boilers, and combined cycle power generators. Gas is not so abundant or widely spread as to be a panacea, however, and technologies have yet to be developed that would make gas an affordable transportation fuel. Major international trade of natural gas is likely to occur only between countries with common borders.[53]

When energy planners first responded to the oil crises of the seventies, nuclear power was at the top of the agenda, expected to serve as the major replacement for oil. In most industrial countries, a large share of government energy investments went to nuclear power. Nuclear construction programs absorbed $120 billion in the United States alone during the past decade. Nuclear power generation worldwide has increased more than fivefold from a small base in 1973. In Western Europe, the Soviet Union, and Japan, nuclear power has contributed greatly to reduced oil use in electricity generation. In North America, on the other hand, nuclear power has had only a small effect on oil consumption.[54]

Nuclear power generation could double during the next decade, given the large number of plants scheduled for completion. After that, it will probably come to a near standstill. During the past five

years, nuclear plant cancellations in the United States have outweighed the sluggish pace of ordering in the rest of the world, which foreshadows a decline in nuclear plant completions in the nineties. Nuclear power now faces myriad obstacles to its further expansion, including safety and regulatory concerns, huge cost overruns, and the unresolved problems of plant decommissioning and waste disposal.

In 1985, nuclear power supplied 3 percent of world energy—about one-third as much as projected by the International Atomic Energy Agency in the mid-seventies. This gives nuclear power the dubious distinction of being the energy source about which official projections erred the most. Based on recent trends and the long time lag in building new plants, nuclear power is unlikely to provide more than 6-8 percent of world energy in the year 2000, even though official government energy plans still call for nuclear power to play a much larger role. Nuclear power, which produces mainly electricity, (some nuclear plants in the Soviet Union are used for district heating) is increasingly irrelevant to the most pressing energy problem—finding a replacement for liquid petroleum fuels. Today the United States gets less than 5 percent of its electricity from oil, Europe 13 percent, and Japan 37 percent. By the early nineties, much of the industrial world, with the notable exception of Japan, will reach the U.S. level.[55]

Renewable energy sources now supply the world with the equivalent of 28 million barrels of oil each day, about six times the nuclear contribution. Of this total, hydropower supplies the equivalent of about 9 million barrels of oil, and woodfuel and various waste materials provide almost 20 million.[56] The important role of these traditional fuels continues to be ignored by most official energy statistics, since they are predominantly used in Third World villages and urban shantytowns. Wood and refuse are not traded in the commercial energy markets studied by analysts in Paris and Washington.

Until the mid-seventies, it was assumed that reliance on traditional fuels would fade, as had happened during the industrialization of Europe and North America. Yet today the importance of renewable energy sources is steadily growing. They provide 18 percent of world energy but satisfy the energy needs of a larger number of people than

does any other energy source. How renewable energy sources are managed is one of the most important yet most neglected links in the world energy future.

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Since 1973 wood has made a notable comeback as a residential and industrial fuel in North America, most of it serving as a direct substitute for oil. Hydropower generation is growing rapidly as well, particularly in developing countries, where scores of large projects have been completed in the past decade. In fact, the World Bank reports that many countries with small electricity grids will have difficulty finding uses for all of their newly harnessed hydropower. So far, other sources of renewable energy such as wind, solar, geothermal, and advanced bio-energy systems have contributed only slightly to the global energy budget, but their share is now growing rapidly. Several of these new energy technologies are moving quickly toward commercial development, despite the recent weakness in oil prices.[57]

Use of the most heavily exploited renewable energy source—woodfuel in the Third World—is growing the slowest, at a 1-2 percent rate. Shrinking forests and rising wood prices are forcing millions of people to cut consumption to the bare minimum. Although such trends are customarily excluded from global energy statistics, they are interconnected and will become more so in the future. If oil prices had not risen during the seventies, both industries and individual consumers would be using more oil. Because of the oil shocks, petroleum consumption is lower and pressures on natural resource systems are greater. Many people have had to burn agricultural residues that otherwise would be used for fertilizer. As in industrial countries, higher oil prices would boost demand for alternative fuels, but in the Third World, substituting a new energy source is not a simple matter. Less productive soils and more time spent gathering fuelwood are costs that many peasants pay to help lower world oil prices.[58]

Energy efficiency, broadly defined, has been the most important replacement for oil, exceeding the contribution of all new energy sources combined. Aggregate energy figures for the Western industrial countries indicate that efficiency accounts for over half of the 36 percent decline in the energy-GNP ratio since 1973.[59] Until the seven-

"Energy efficiency has been the most important replacement for oil, exceeding the contribution of all new energy sources combined."

ties, energy projections were generally made by forecasting economic growth and assuming that energy needs would grow at about the same pace. Although these assumptions were challenged by several major studies in the seventies, most national governments and international agencies continued to forecast only slight efficiency improvements and continuing steady growth in energy needs.

In fact, energy efficiency improvements over the past decade have outstripped even the more optimistic forecasts and continue to exceed annually revised national projections. The United States, starting with one of the world's most energy-intensive economies, has achieved one of the most dramatic turnarounds. Between 1973 and 1984, the real U.S. gross national product (after discounting for inflation and the effect of higher energy expenditures) rose 30 percent. Yet energy use in 1984 was slightly lower than in 1973. As measured by the energy/GNP ratio, U.S. energy efficiency rose 23 percent during the period. Without this increased efficiency, U.S. energy use in 1984 would be higher by the equivalent of 10 million barrels of oil per day, or about double 1984 oil imports. Annual U.S. energy expenditures would be at least $100 billion higher. Coal, by comparison, has provided the equivalent of an additional 2 million barrels of oil per day, and nuclear power has provided just over one million barrels per day.[60]

Western Europe, starting with substantially more efficient economies, realized a 16 percent decline in its energy-intensity between 1973 and 1984. Japan led the world with a remarkable 29 percent decline in its energy-GNP ratio, reflecting a broad array of efforts by industry and government to reduce oil dependence. In Greece and Australia, on the other hand, energy intensity actually rose during the past decade. Data compiled by the International Energy Agency show GNP in the OECD countries rising 24 percent between 1973 and 1984, while total energy use was unchanged. This indicates a 19 percent drop in the energy/GNP ratio, consistent with the numbers cited above.[61] (See Table 9.)

Efficiency improvements in economies around the world are caused in part by simple housekeeping measures (turning down thermostats and driving slower), in part by structural changes such as the de-

Table 9: Energy Intensity of Economic Activity in Selected Countries

	1973	1979	1984	Projection 2000	Change 1973-1984
	(metric tons of oil equivalent per $1000 of GDP)				(percent)
Australia	0.68	0.73	0.70	0.63	+ 3
Canada	1.14	1.16	1.09	1.02	- 4
Germany	0.64	0.59	0.52	0.34	-19
Greece	0.59	0.63	0.64	0.77	+ 8
Italy	0.69	0.64	0.57	0.53	-17
Japan	0.70	0.61	0.50	0.38	-29
Sweden	0.69	0.67	0.64	0.48	- 7
Turkey	0.84	0.76	0.76	0.80	-10
United Kingdom	0.93	0.85	0.73	0.66	-22
United States	1.14	1.05	0.90	0.72	-21
All OECD Countries	0.90	0.84	0.73	0.59	-19

Note: Figures are standardized to show total primary energy use per U.S. $1000 of gross domestic product at 1975 prices and exchange rates.

Source: International Energy Agency, *Energy Policies and Programmes of IEA Countries, 1984 Review*.

velopment of less energy-intensive service economies or communities where cars are not needed as often, and in part by technological improvements such as more efficiently designed homes, automobiles, and appliances. The first wave of efficiency improvements in the seventies was dominated by housekeeping measures, but these fell off once the easy steps had been taken and energy price increases slowed.[62]

Structural and technological energy efficiency improvements are accelerating, however. The movement away from energy-intensive,

heavy-industry-dominated economic systems is driven by major social and economic forces as well as by high energy costs, and so has not been greatly affected by the recent decline in oil prices. The latest generation of virtually all energy-using technologies is more efficient than the one that preceded it. In practice, the structural economic changes that cause lower oil use are hard to distinguish from the technological changes that occur purely in response to energy prices. Most analysts believe that the latter are more important in explaining recent energy trends, but precise percentages cannot be assigned.[63]

Many energy-efficient technologies took years to develop and are just now coming on the market. Economic recovery has caused a surge in the purchase of automobiles, appliances, and industrial equipment. As the older equipment is replaced, energy efficiency generally improves. Lower energy prices cause consumers to be less discriminating when they shop for cars or appliances, but even the less energy-efficient equipment on the market today is usually a big improvement over its predecessor. So far, however, few consumers have enjoyed significantly lower energy prices. Electricity prices continue to rise in most countries, natural gas prices have remained steady or risen slightly, and, except in the United States, the real price of oil has barely declined. Efficiency improvements still offer large economic rewards, although consumer fervor over energy prices is not as great as it was a few years ago.[64]

Anticipating the future pace of energy efficiency improvements is difficult. On the one hand, some of the easiest changes have already occured. The growth of the service sector is slowing, millions of houses have already been weatherized, and cars are unlikely to get much smaller. On the other hand, a profusion of new, more energy-efficient technologies is just becoming available. New automotive technologies could raise new car fuel economy from the current average of 25-30 miles per gallon to over 50 miles per gallon. Pulse combustion gas furnaces now use 28 percent less fuel than traditional furnaces. Fluorescent socket-type light bulbs introduced by several companies in 1984 and 1985 use 65-75 percent less electricity than conventional light bulbs. (They cost $10-$20 and last 5-10 times as

long.) The most advanced steel plants using virgin ore are over 25 percent more efficient than the world's average steel plant. New "mini-mills" that use recycled steel are even more efficient.[65]

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Although energy-efficient technologies continue to proliferate, their long-range contribution remains one of the largest uncertainties in the global energy future. Energy efficiency gains have been slowed by a shortage of good information and investment capital, particularly for consumers who are in the best position to make many of the improvements. Although energy efficiency ranks higher on national energy planning agendas than it once did, most energy policymakers still give efficiency low priority (and far lower investments) than oil exploration or power plant construction.

Even without more government attention and reform of policies that discourage greater energy efficiency, substantial gains are likely during the next decade. But new efforts will be needed to extend efficiency improvements beyond the early nineties, and they will have to begin soon. The efficiency of new homes and automobiles has leveled off since the early eighties in Europe and North America, which could portend a slowdown in improving the efficiency of the total housing stock and automobile fleet. Automobiles and other forms of transportation are particularly critical to the world energy future since they are generally run on liquid fuels derived from oil. By the year 2000, transportation will claim a much larger share of world oil—up to 51 percent in industrial countries, and perhaps almost as high in the Third World, where use of energy for transportation is growing the most rapidly. Since affordable alternatives to petroleum for transportation have yet to be found except in a few isolated countries, the energy efficiency of the world's automobiles, trucks, and planes, is a key factor in the world energy future.[66]

A global end-use oriented energy strategy developed by the Princeton Center for Energy and Environmental Studies concludes that if available resources were used efficiently, the world could in the year 2020 support a population of 7 billion people with a much higher standard of living on about the current energy budget.[67] Such a scenario is only possible if major energy efficiency improvements are

made in developing as well as in industrial countries. Even with these improvements, the Third World would use two-thirds of the world's energy, up from one-third in 1985.

Developing countries face enormous obstacles in attempting to improve energy efficiency. Third World factories often consume two to five times more fuel for a given process compared to state-of-the-art technologies in industrial countries. Decades-old industrial equipment and a frequent shortage of trained personnel to perform simple maintenance and retrofits makes the situation worse.[68] Because Third World factories often must produce a regulated amount of goods at a fixed price, there is little incentive to lower energy costs. Raising Third World energy efficency is one of the world's most difficult and most important challenges. Success in improving Third World energy efficiency will greatly influence both the development process and the future of the world oil market.

A New Energy Policy Framework

For the past decade, energy analysts and policymakers have struggled with energy systems that stubbornly refused to conform to their predictions. The annual downward revisions of energy growth projections made by organizations ranging from the U.S. Edison Electric Institute to the European Economic Commission have become almost as predictable as energy trends once were. Not until the early eighties did most government forecasters accept that the link between economic growth and energy growth had been broken. The rapid decline of oil's role in the world economy has also surprised analysts who generally expected economic recovery to bring a quick end to the oil glut. Only since 1984 have official projections recognized that falling oil prices are more than a short-term aberration.

Even in 1985, the U.S. Department of Energy, the International Energy Agency, and several private oil companies project that world oil consumption will grow 5-10 percent by 1990, and that real oil prices will be higher than they are in 1985.[69] Like generals preparing to fight the last war, energy policymakers appear to be getting ready for the

last energy crisis, spending vast sums on large energy projects that will be economical only if oil prices rise.

48 It is time to recognize that the oil glut is real and likely to be protracted. Fundamental changes have greatly lowered the demand for oil and have helped provide significant new supplies. Declining oil prices and falling demand for OPEC oil may be key features of the world energy scene for several years. Energy problems have not disappeared, but they have changed greatly, and new strategies are needed. The challenge is to sustain the positive momentum that has developed in recent years, and, amid conditions that cry out for complacency, prepare for a time when oil will be prohibitively expensive throughout most of the world.

The immediate outlook is not likely to warm the hearts of OPEC oil ministers. Oil consumption in the industrial countries is likely to fall another 2-3 million barrels per day during the next several years, according to recent studies.[70] Billions of dollars worth of investments in more efficient technologies and alternative energy sources were made over the past decade and will continue to bear fruit in the years ahead. Recent declines in oil prices have so far had little impact on these trends and are unlikely to for some years to come. Many of these investments make sense even if oil prices fall to $20 per barrel. Opportunities to save money by reducing oil consumption are actually greater now than they were five years ago, when prices were substantially higher.

Third World oil consumption is likely to increase by 6-8 million barrels per day by 1995, according to the World Bank.[71] This may be an overestimate, however, given the serious economic problems of many developing countries and the continuing high cost of oil in Third World currencies. Slower economic growth in oil-exporting countries is also likely to restrict the share of oil they retain for domestic use. Additional demand for oil in developing countries in 1990 is unlikely to greatly exceed the decline in industrial country consumption. This would leave world oil consumption in 1990 at less than 60 million barrels per day, up only slightly from 1985.[72]

"OPEC's tenuous control over world oil markets continues to slip."

Non-OPEC oil production will add 1-2 million barrels per day to the world oil supply by 1990, which means that world demand for OPEC oil is unlikely to exceed its current level during the next five years and could even fall slightly. This outlook portends a deepening economic crisis for many OPEC countries. Government expenditures have already exceeded revenues in at least 14 of the 17 OPEC countries for the past three years.[73] Most are following a strategy of waiting out the oil glut, drawing down foreign currency reserves or accumulating debts as they wait for the assumed turnaround in world oil markets.

The last several OPEC meetings have revealed growing strains among OPEC's diverse membership. Official prices have been gradually lowered to reflect spot market prices at which much OPEC oil is sold. The more important production ceilings have been gradually lowered in an attempt to end the oil glut, but economic problems have led many countries to violate the agreements. OPEC's tenuous control over world oil markets continues to slip. Rotterdam and New York are filled with rumors of oil being bartered for commercial airliners, armaments, and other merchandise, a way of circumventing price and quota restrictions. As world oil markets become more competitive and diverse, the ability to enforce quotas and prices diminishes. OPEC countries are refining a growing fraction of their oil internally before export. Because markets for refined oil products are so complex, OPEC has been unable to include them in its agreements, and they are traded competitively on international markets.[74]

Since the late seventies, Saudi Arabia, with the world's largest oil reserves, has played the key role as OPEC's "swing producer," raising and lowering production in accordance with world market trends and thereby bringing some stability to the oil picture. In early 1985 this brought Saudi oil production to its lowest level in two decades, and most signs indicate that it will "swing" no lower. Saudi oil production is now only half the level required to maintain the country's already truncated industrialization program, and analysts believe that political unrest may not be far off if the country's economic malaise is allowed to deepen. Saudi oil minister Ahmed Zaki Yamani has suggested his country might unilaterally raise production and lower prices unless other OPEC members adhere more faithfully to

OPEC rules. Although Saudi Arabia has failed to carry through on such threats in the past, the country's worsening economic situation may demand such harsh actions.[75]

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Other OPEC countries have even less maneuvering room. Mounting debts and economic austerity programs are now almost as common in oil exporting countries as they are in the rest of the Third World. Deteriorating economies and internal stress make strict adherence to OPEC quotas and prices virtual political suicide in many countries. The Iran-Iraq war, which has restricted production in both of those countries to less than their OPEC quotas, is an additional wildcard in the OPEC struggle. Despite the continuation of the war, Iraq may soon complete a pipeline that will add as much as one million barrels per day to world oil supplies, and a complete end to the war could boost the output of those countries by an estimated 2-3 million barrels per day.[76]

The world oil market in 1985 is as unpredictable as it has been at any time since the Iranian Revolution. Growing economic and political strains threaten to tear OPEC's delicate fabric of accommodation. As in the past, oil's future will be governed as much by political developments as by economics, but unlike in the seventies, the risks are now on the side of a downward cascade in prices and perhaps even a collapse of OPEC. Political leaders of several member countries have talked seriously about leaving OPEC. Most OPEC members have a great deal to lose if the cartel were to collapse and will work hard to prevent it, but they face formidable odds given the direction of world energy trends and the ever more fractious politics of the Middle East.

Downward pressure on oil prices is virtually inevitable during the next several years, and a sudden fall in prices to under $20 per barrel is a real possibility. This would certainly benefit the world economy in the short run, but probably far less than most economists assume. Since oil's role has diminished, and many industries have made investments that commit them to using energy sources other than oil, the stimulative effect of falling oil prices would be far less than in the seventies. More important, a sudden fall in oil prices threatens to

"Growing economic and political strains threaten to tear OPEC's delicate fabric of political accommodation."

establish a "crisis and glut" cycle that makes it difficult for companies, governments, and individuals to make sound long-term decisions about energy investments.

Without reinvigorated efforts, recent improvements in the world energy situation will run out of steam by the early nineties. By then the world economy will be substantially more energy-efficient than it is today. Oil will have been largely eliminated as a fuel for power plants and many industries. Natural gas will play a much more central role in the world economy, and coal, renewable energy sources, and nuclear power will also have expanded.

Oil is still likely to provide about 30 percent of the world's energy in the nineties, and its use will be increasingly concentrated in transportation and petrochemicals, two areas where substitution by other energy sources has so far shown little success. If oil prices continue to fall during the next five to ten years, they will severely slow efforts to improve energy efficiency and to develop alternative energy sources. Industry leaders and consumers would inevitably give energy efficiency investments lower priority, and research on new technologies would suffer. The International Energy Agency reports that many industrial countries already have trimmed their energy conservation programs.[77]

Growth in oil consumption during the nineties is likely to be propelled largely by increasing Third World consumption, particularly in the rapidly expanding economies of Latin America and the Far East. Developing countries now use only a tiny share of the world's oil and this is bound to change in the years ahead. (See Figure 8.) A continuing inability to acquire the technologies or management skills needed to reach the very high levels of energy efficiency now being attained in some industrial countries make for a rather bleak energy outlook in many Third World nations. Those countries that are economically healthy enough to afford oil are likely to boost petroleum imports in the next decade.[78]

Although today's energy challenge is less immediate than that of the recent past, it is no less daunting. Rapid growth in world oil consumption threatens to resume in the early nineties when the physical

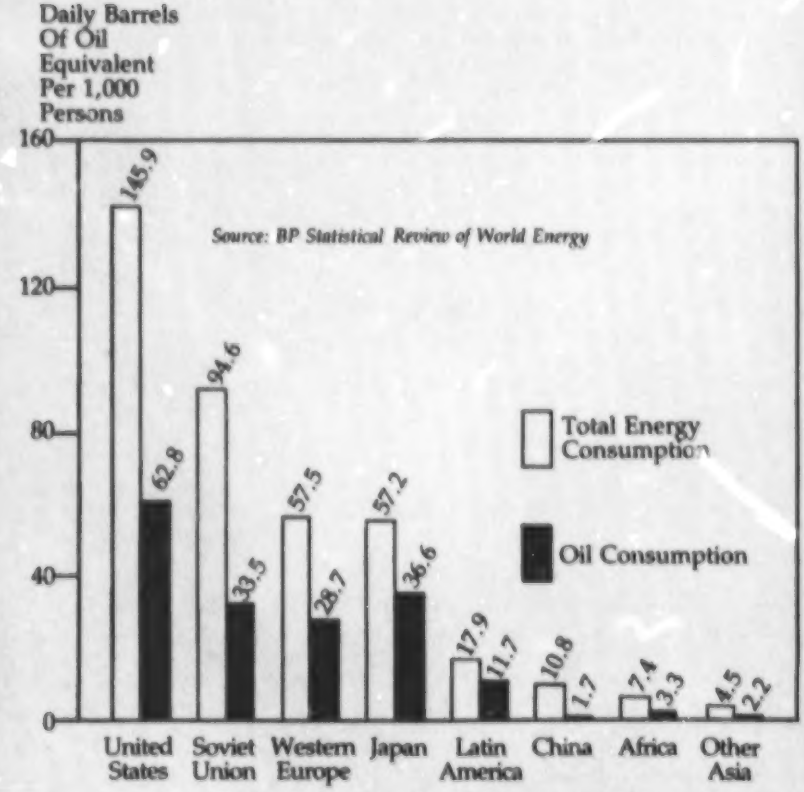

Figure 8: Energy Consumption Per Capita By Region, 1983

limits of non-Middle Eastern oil production will have been reached, causing production to decline steadily. A smaller and more cohesive OPEC could easily control as much as half of the world oil market by

the end of the century, leaving the world more vulnerable than ever to political instability in the Middle East.

OPEC is not the enemy, however. Both oil exporters and importers will be better off in the long run if oil markets become more stable. Only then are oil importers likely to continue building non-oil-based economies without undergoing debilitating economic recessions. Only with a stable world oil market are exporters likely to enjoy the political and economic tranquility needed to effectively exploit their enormous oil revenues. Maintaining the current momentum away from dependence on oil is essential to such stability.

Energy policy guidelines for the next decade must start with the past decade's most important lesson: given the right incentives, energy markets work. Crash government programs to develop major new energy sources have in general been dismal failures, and similar efforts to deal with future crises show no signs of being any more successful. But smaller efforts, taken by companies and individuals in response to higher prices, have an excellent record.

The transition from an oil market dominated by the pricing decisions of a few multinational corporations and OPEC countries to one driven by the competitive interplay of thousands of buyers and sellers has generally been positive. Price fluctuations have been less severe, and the economic signals for consumers have been more constant. Analysts believe that more competitive oil markets are likely to ease the effect of future disruptions, though it is uncertain whether the enhanced competition will continue as Middle Eastern oil producers become more dominant in the nineties.[79]

The easing of market restrictions has helped propel the recent energy advances of most industrial countries. It is now clear that price controls on natural gas, both in Europe and North America, caused artificial shortages during the seventies. At the same time, large government subsidies produced many uneconomical and unnecessary power plants. Decontrol of oil and natural gas prices in the United States helped lead to greater production and more efficient use of these energy sources. Higher energy prices have caused a virtual

revolution in the development of energy-efficient technologies. The research stimulated by higher prices continues to yield dozens of promising new technologies each year.

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The world's energy markets are still impeded by a number of inefficient or counterproductive government policies. Many national tax systems provide subsidies to a variety of energy industries, often encouraging investments that would otherwise not be economical. In the United States, oil companies can deduct "intangible drilling expenses" to compensate for exploration risks and a "percentage depletion allowance" as compensation for the loss of future revenues as oil reserves are drawn down. In most countries, power plant construction receives special tax credits and low-interest loans, reflecting the almost mythic role that electrification has played in industrialization. More recently, many industrial countries have encouraged investments in energy efficiency and renewable energy sources by enacting tax credits, grants, and subsidized loans.[80]

While the motivations for such subsidies are often worthy, they generally do more harm than good, favoring one energy source over another on political rather than on sound economic or environmental grounds. The United States alone provided about $46 billion in energy subsidies in 1984. In Europe, the largest subsidies went to nuclear construction programs financed directly through government treasuries or through special financial concessions. Tax loopholes for the U.S. oil industry, aptly named the "drain America first" policy, have depleted U.S. oil reserves at a far faster pace than in other countries. The Netherlands made the opposite error, artificially pricing natural gas on a par with imported oil, which discouraged industries from using gas and caused greater dependence on electricity and imported oil.

Many counterproductive tax credits and subsidies have been removed in recent years, but others remain and continue to impede progress toward an economical and sustainable energy future. The first draft of the Reagan administration's 1985 tax reform proposal called for elimination of virtually all of the special energy tax credits in the U.S. tax code. After an intense round of lobbying by oil and utility industry lobbyists, however, the second draft of the proposal

restored most of the credits. Oil and utilities are two of the world's largest industries, exerting considerable influence on policy deliberations in which they have a stake. Reform of this irrational scheme of subsidies will require an enormous political effort by citizens and the many other industries who pay the price of such policies.

Government energy subsidies are often justified on broad economic and national security grounds. Power shortages and heavier reliance on imported oil are predicted if the subsidies are eliminated. But domestic energy sources compete against one another as much as they compete against imported oil, and so special subsidies for coal or nuclear power often have the unfortunate effect of discouraging the development of less expensive and cleaner energy sources. Energy efficiency investments are particularly discouraged by the subsidies provided to energy industries. In some cases, energy subsidies may actually encourage greater reliance on imported oil by discouraging the development of more energy-efficient technologies that otherwise would have been ready the next time energy prices begin to climb.

The centrally planned economies of Eastern Europe and the Soviet Union face some of the most difficult challenges in reforming energy markets. There, energy efficiency has not improved significantly in the past decade, largely because artificially low prices have insulated consumers and industrial managers from rising world energy prices. The Soviet Union has the world's second least energy-efficient steel industry, even though it is one of the largest and best established. Centrally planned economies favor large-scale projects over changes that require thousands of smaller efforts. The energy inefficiency of the Soviet economy undermines its efforts to compete in world markets, but recent economic reforms appear intended in part to address these problems.[81]

Many developing countries have also failed to harness market forces effectively. Energy price subsidies for the poor and complex price support systems for various industries leave Third World consumers with little sense of the real cost of different energy options. As a result, those countries that can least afford to waste energy often have the least efficient homes and factories. But simply raising energy prices can cause riots in Third World cities and will not in any case be

sufficient to solve these problems. First, improved management and less rigidly structured industries are needed so that market signals can be properly used. The poor must also be provided with affordable options. Many opportunities exist for the exchange of technologies and information on energy efficiency with industrial countries. If even a fraction of the effort devoted to aggressively marketing nuclear power in the Third World were turned to industry reforms and efficient technologies, enormous progress could be made.[82]

Although freer energy markets are central to any effective energy strategy, they will require fine-tuning to meet the challenges of the next decade. The main challenge is that oil prices are likely to continue falling in coming years, sending consumers a message that could eventually lead to higher oil consumption and a future crisis. As in the early seventies, oil's price may drop below its long-term replacement value in most countries. This would undermine energy efficiency investments and the development of indigenous energy sources. In the next few years, energy investments in many countries may be unable to compete in cost with Middle Eastern oil, which still comes out of the ground for only a few dollars a barrel.

The current period of falling oil prices is a logical time for governments to step in with taxes on imported oil. Such a tax insulates domestic energy markets from international competitors but does not interfere with the choices between indigenous energy sources—choices that should be made on sound economic and environmental grounds. Such a tax could be levied to keep real oil prices at a fixed level or cause them to rise slowly over time. Alternatively, efforts to progressively raise the tax on gasoline and diesel fuel—the most intractable oil users—would be a major step forward.

Oil import taxes obviously present enormous political difficulties, both within and between countries. Periodic efforts to enact such a tax have failed in several countries in recent years. However, the time may be right given the difficulties lower oil prices are beginning to cause for domestic energy producers in many countries. The International Energy Agency has even proposed an international agreement to enact such a tax—to ensure that industries in some countries are not disadvantaged.[83]

Energy efficiency standards are also badly needed to supplement market forces in coming years. The purchase of an automobile or a major appliance such as a refrigerator effectively commits an individual to a particular level of energy consumption for 5-20 years, during which time the cost of energy may shift repeatedly. Consumers often have no way of knowing what those costs will be, and they cannot always afford the up-front costs of making sound, long-term investments.

In several countries, governments have forced manufacturers of automobiles and major appliances to meet certain proscribed efficiency standards.[84] But many of those standards are now outdated, some are about to expire, and manufacturers are fighting to weaken those that remain. Efficiency standards should either be extended and toughened or replaced with government incentives that encourage sound energy investments. Sales taxes based on the energy requirements of particular appliances would provide manufacturers and consumers more flexibility and might in the long-run stimulate research and accelerate development of efficient technologies. The key to making such policies equitable and workable is to provide an economic signal but allow consumers and manufacturers to make the actual decisions.

The enormous strides away from oil dependence in the past decade provide much reason for optimism. Opportunities to increase energy self-sufficiency and even eliminate the need for imported oil are far greater in many countries than at any time in modern history. But dangers are hidden among the recent successes. The momentum achieved can only be sustained by major changes in energy policies in the years ahead. The key test is whether the political will for such change can be mobilized in the absence of an immediate crisis.

Notes

1. World oil statistics in this paper, unless otherwise noted, are from British Petroleum Company, *BP Statistical Review of World Energy* (London: 1985). The average world oil price used here is a composite figure, based on a weighted average of domestic and imported crude oil at the U.S. refinery gate as listed in U.S. Energy Information Administration, *Monthly Energy Review* (Washington, D.C.: April 1985).

2. *BP Statistical Review of World Energy*. These figures include about 4 million barrels per day of natural gas liquids. The oil production figures in Figure 1. are from the American Petroleum Institute, *Basic Petroleum Data Book*, Vol. 5, No. 2 (Washington, D.C.: 1985), and do not include gas liquids. For representative late seventies forecasts, see Gulf Oil Corporation, "World Petroleum Outlook," unpublished, November 1978, and U.S. Central Intelligence Agency, "The World Oil Market in the Years Ahead," unpublished, July 1979.

3. The official OPEC price is for Saudi Arabia's light crude oil, priced at $34 in 1981 and lowered to $28 in late 1984; see *BP Statistical Review of World Energy*.

4. *BP Statistical Review of World Energy*. Oil/GNP figure is from International Energy Agency, *Annual Oil Market Report, 1984* (Paris: Organisation for Economic Cooperation and Development, 1985).

5. Youssef M. Ibrahim and Allanna Sullivan, "Strength in Oil Prices Isn't Likely to Last, Many Analysts Think," *Wall Street Journal*, April 23, 1985.

6. Lee A. Daniels, "OPEC's Pricing Predicament," *New York Times*, June 10, 1985.

7. Youssef M. Ibrahim, "Saudis Warn OPEC That They Will End Oil-Price Props if Discounting Persists," *Wall Street Journal*, June 4, 1985.

8. OPEC revenues from *Petroleum Intelligence Weekly*, April 23, 1984 and February 23, 1981. Oxford Institute study is described in Roger Vielvoye, "OPEC Oil Outlook," *Oil and Gas Journal*, May 27, 1985.

9. Richard J. Meislin, "Mexico Encounters Problem of Growth," *New York Times*, June 10, 1985; Sandra Feustel, "Lower Oil Prices End 'Gold Dust Days' on Persian Gulf," *Washington Post*, January 15, 1984; David B. Ottaway, "Saudi Arabia: The Boom Ends" (a series), *Washington Post*, November 25-27, 1984.

10. U.S. Department of Energy, *Annual Energy Review 1984* (Washington D.C.: 1985); Edward Boyer, "Winners and Losers from Cheaper Oil," *Fortune*, November 26, 1984.

11. *API Basic Petroleum Data Book*; International Monetary Fund, "International Financial Statistics," Washington, D.C., March 1985.

12. Philip K. Verleger, *CRA Petroleum Economics Monthly*, Charles River Associates, Boston Massachusetts, May 14, 1985.

13. "Soviets Demand More from East Bloc Allies," *Washington Post*, June 17, 1985.

14. Ed A. Hewett, *Energy Economics and Foreign Policy in the Soviet Union*, (Washington, D.C.: The Brookings Institution, 1984).

15. The World Bank, *World Development Report 1984* (New York: Oxford University Press, 1984). Brazil figure is from Howard Geller, The American Council for an Energy-Efficient Economy, private communication, June 21, 1985.

16. Clyde H. Farnsworth, "Cuban Report Is Candid On Economic Burdens," *New York Times*, June 5, 1985; "Sudan to Get $40 million," *Washington Post*, April 11, 1985.

17. The World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: 1983).

18. *API Basic Petroleum Data Book*.

19. Richard Nehring, "Prospects for Conventional World Oil Resources," *Annual Review of Energy* (Palo Alto, Calif.: Annual Reports Inc., 1982).

20. Nehring, "Prospects for Conventional World Oil Resources;" Charles D. Masters, "World Petroleum Resources: A Perspective," U.S. Geological Survey, unpublished, 1985.

21. Nehring, "Prospects for Conventional World Oil Resources."

22. Ibid.

23. Charles D. Masters, David H. Root, and William D. Dietzman, "Distribution and Quantitative Assessment of World Crude-Oil Reserves and Resources," U.S. Geological Survey, unpublished, 1983.

24. Ibid.

25. Oil production figures include all crude oil and natural gas liquids outside Alaska and are from U.S. E.I.A., *Monthly Energy Review;* John H. Lichtblau, "OPEC Oil in a Global Context: The Next 10 Years," lecture delivered at seminar on The Future of OPEC, The Centre for OPEC Studies, Caracas, Venezuela, April 25, 1985.

26. U.S. Congress, Office of Technology Assessment, *Oil and Gas Technologies for the Arctic and Deepwater* (Washington, D.C.: 1985).

27. "Alaska Drilling: Disappointments," *Energy Daily*, March 29, 1985; Bob Williams, "Apparent Mukluk Wildcat Failure Doesn't Dim North Slope Outlook," *Oil and Gas Journal*, January 16, 1984; Mark Potts, "Oil Hopes Dashed in Atlantic," *Washington Post*, December 23, 1984.

28. Lichtblau, "OPEC Oil in a Global Context"; U.S. oil production projections studied for this report include U.S. Department of Energy, *Energy Projections to the Year 2000*, (Washington, D.C.: 1983), U.S. Energy Information Administration, *Annual Energy Outlook 1984* (Washington, D.C.: 1985), Chevron Corporation, *World Energy Outlook* (San Francisco, Calif.: 1985), and Conoco Inc., *World Energy Outlook Through 2000* (Wilmington, Del.: 1985).

29. "Soviet Drilling Program Shy of Target," *Oil and Gas Journal*, April 29, 1985; "Soviet Oil Output Still Below Target," *Journal of Commerce*, June 17, 1985.

30. "Soviets Seek to Stir Up Stagnant Oil Sector," *Journal of Commerce*, March 25, 1985; Leonard Silk, "Soviet Oil Troubles," *New York Times*, June 5, 1985.

31. "Oil Production Up, Activity Levels High Off Northern Europe," *Oil and Gas Journal*, June 10, 1985.

32. William A. Orme, "Mexican Oil Dependence Grows," *Journal of Commerce*, June 14, 1985; William A. Orme, "Reserve Estimate Declines in Mexico," *Journal of Commerce*, March 20, 1985.

33. Peter Hills, "China's Offshore Oil Boom," *New Scientist*, September 8, 1983; Amanda Bennett, "Promise of China's Oil Starts Slowly Changing People and Landscape," *Wall Street Journal*, February 5, 1985.

34. Kim Woodard, China Energy Ventures Inc., "Development of China's

Petroleum Industry: An Overview," prepared for the China Energy Workshop, East-West Center, Honolulu, Hawaii, April 25-26, 1985.

35. The World Bank, *Energy Transition in Developing Countries;* updated information from Farrokh Najmabadi, World Bank petroleum economist, private communication, June 28, 1985.

36. Lichtblau, "OPEC Oil in a Global Context."

37. Charles Ebinger, Georgetown University Center for Strategic and International Studies, private communication, June 13, 1985.

38. Ibid.

39. Lichtblau, "OPEC Oil in a Global Context"; H. Tahmassebi, "World Energy Outlook Through 1990," Ashland Oil Inc., unpublished, June 1984.

40. International Energy Agency, *Annual Oil Market Report*, 1984.

41. International Energy Agency, *Coal Information 1984* (Paris: Organisation for Economic Co-operation and Development, 1984).

42. The World Coal Study, *Coal: Bridge to the Future* (Cambridge, Mass.: Ballinger Publishing Company, 1980); International Institute for Applied Systems Analysis, *Energy in a Finite World* (Cambridge, Mass.: Ballinger Publishing Company, 1981).

43. Energy Information Administration, *Monthly Energy Review;* coal market trends described in *Energy Daily*, various issues.

44. Energy Information Administration, *Monthly Energy Review;* World Bank, *Energy Transition in Developing Countries*.

45. U.S. trends from *Energy Daily*, various articles. International trends from International Energy Agency, *Energy Policies and Programmes of IEA Countries: 1984 Review* (Paris: Organisation for Economic Co-operation and Development, 1985).

46. Sandra Postel, "Protecting Forests from Air Pollution and Acid Rain," in Worldwatch Institute, *State of the World 1985* (New York: W.W. Norton & Company, 1985).

47. World natural gas production and reserve figures are from *BP Statistical Review of World Energy*.

48. Exxon Corporation, *Middle East Oil and Gas* (New York: 1984).

49. "Natural Gas: World Status," *Financial Times Energy Economist*, March 1984.

50. Marcia A. Parker, "Less Developed Countries Push Campaigns to Tap Natural Gas," *Oil and Gas Journal*, June 1985.

51. The World Bank, *The Energy Transition in Developing Countries*. World Bank loan figures are from Robert Sato, World Bank senior energy advisor, private communication, April 6, 1985.

52. Official government projections of steadily declining gas production are reflected in International Energy Agency, *Energy Policies and Programmes of IEA Countries: 1984 Review*. An alternative gas projection for Europe is included in Energy Advice, *Energy Supplies and Prices in Western Europe to the Year 2000* (Geneva, Switzerland: 1985); U.S. Congress, Office of Technology Assessment, *U.S. Natural Gas Availability: Gas Supply Through the Year 2000* (Washington, D.C.: 1985).

53. Office of Technology Assessment, *U.S. Natural Gas Availability*; Charles J. Mankin, "Unconventional Sources of Natural Gas," in *Annual Review of Energy* (Palo Alto, Calif.: Annual Reviews Inc., 1983); "Relevant R&D: A Conversation with the Guru of Gas Research," *Energy Daily*, June 16, 1983.

54. Christopher Flavin, *Nuclear Power: The Market Test* (Washington, D.C.: Worldwatch Institute, 1983).

55. Nuclear power projections of the mid-seventies are included in Organisation for Economic Co-operation and Development, *World Energy Outlook* (Paris: 1977). The current outlook is described in International Energy Agency, *Energy Policies and Programmes of IEA Countries*.

56. Hydropower figures are from *BP Statistical Review of World Energy*. Biomass figures are Worldwatch Institute estimates based on Keith Openshaw, "Woodfuel -- A Time for Re-Assessment," *Natural Resources Forum*, 1978; see also Daniel Deudney and Christopher Flavin, Renewable Energy: *The Power to Choose* (New York: W.W. Norton & Co., 1983).

57. Third World hydropower prospects described in unpublished World Bank reports. Recent commercial developments in renewable energy described in Christopher Flavin, *Renewable Energy at the Crossroads* (Washington, D.C.: Center for Renewable Resources, 1985).

58. Erik Eckholm, et al., *Fuelwood: The Energy Crisis That Won't Go Away* (London and Washington, D.C.: Earthscan, 1984).

64

59. Efficiency's contribution estimated by comparing the 30 percent decline in the oil-GNP ratio with the 19 percent decline in the energy-GNP ratio between 1973 and 1984.

60. U.S. energy-GNP figures are found in Energy Information Administration, *Monthly Energy Review*. An adjusted calculation discounting for the effects of higher energy expenditures on GNP estimates was provided by Howard Geller, American Council for an Energy-Efficient Economy, private communication, June 21, 1985. Dollar saving from increased efficiency is based on a total 1984 energy bill of $603 billion or $8.15 per million BTU which would have been $790 billion if the energy-GNP ratio had remained at the 1973 level and the country had used 96 quadrillion BTU's of energy compared to 74 quadrillion BTU's of actual use.

61. International Energy Agency, *Energy Policies and Programmes of IEA Countries*.

62. Eric Hirst, et al., "Recent Changes in U.S. Energy Consumption: What Happened and Why," in *Annual Review of Energy*, (Palo Alto, Calif.: Annual Reviews, Inc., 1983).

63. U.S. Department of Energy, Office of Policy Planning and Analysis, "Energy Use Trends in the United States, 1972-1984," draft report, May 1985; Marc Ross, "Industrial Energy Conservation," *Natural Resources Forum*, April 1984.

64. William U. Chandler, *Energy Productivity: Key to Environmental Protection and Economic Progress* (Washington, D.C.: Worldwatch Institute, 1985).

65. Ibid. Light bulb example is from Howard Geller, private communication, June 21, 1985.

66. International Energy Agency, *Fuel Efficiency of Passenger Cars* (Paris: Organisation for Economic Co-operation and Development, 1984).

67. Jose Golemberg, et al., *An End-Use Oriented Global Energy Strategy* (Princeton, N.J.: Princeton University Center for Energy and Environmental Studies, 1985).

68. Alain Streicher, Hagler Bailly & Company, Inc., private communication, June 20, 1985.

69. U.S. Department of Energy, *Energy Projections to the Year 2000;* U.S. Energy Information Administration, *Annual Energy Outlook 1984* (Washington, D.C.: 1985); International Energy Agency, *Energy Policies and Programmes of IEA Countries;* Chevron Corporation, *World Energy Outlook;* Conoco Inc., *World Energy Outlook Through 2000.*

70. Dale W. Steffes, "Conservation and the Energy Demand Outlook," paper presented to the 12th Energy Technology Conference, Washington, D.C., March 25-27, 1985; Energy Advice, *Energy Supplies and Prices in Western Europe to the Year 2000.*

71. The World Bank, *Energy Transition in Developing Countries.*

72. A slightly higher estimate of 61 million barrels per day based on a consumption growth rate of 1 percent per year is made in John Lichtblau, *OPEC Oil in a Global Context.*

73. International Monetary Fund, *International Financial Statistics,* various dates.

74. Douglas R. Bohi, *Energy Security in the 1980s: Economic and Political Perspectives* (Washington, D.C.: The Brookings Institution, 1984); Frederick H. Gerlach, U.S. State Department, "The New Middle East Export Refineries," paper presented to workshop of the International Association of Energy Economists, Washington, D.C., May 23, 1985.

75. Youssef M. Ibrahim, "Saudis Warn OPEC That They Will End Oil-Price Props if Discounting Persists," *Wall Street Journal,* June 4, 1985.

76. Douglas Bohi, *Energy Security in the 1980s.*

77. International Energy Agency, *Energy Policies and Programmes of IEA Countries.*

78. The World Bank, *The Energy Transition in Developing Countries.*

79. Douglas Bohi, *Energy Security in the 1980s.*

80. International Energy Agency, *Energy Policies and Programmes of IEA Countries;* Richard E. Morgan, "Energy Tax Policy and the Environment," Environmental Action Foundation, unpublishsed, April 1985; Dale Russakoff, "Depletion Write-Off Thrives Despite Conservation's Tug," *Washington Post,* April 21, 1985.

81. Ed A. Hewett, *Energy Economics and Foreign Policy in the Soviet Union.*

82. Alain Streicher, Hagler Bailly & Company, Inc., private communication, June 20, 1985; Michael Fisher, "Innovative Approach to Financing Energy Conservation Investments in Developing Countries," *Natural Resources Forum,* May 1985.

83. International Energy Agency, *Energy Policies and Programmes of IEA Countries.*

84. Ibid.

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